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POWER GENERATION
WATER POWER
DIESEL & GAS ENGINES
AIR CONDITIONING & HEATING
REFRIGERATION
PUMPS & COMPRESSORS
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Volume 80 Number 5

POWER

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MAY, 1936

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Power

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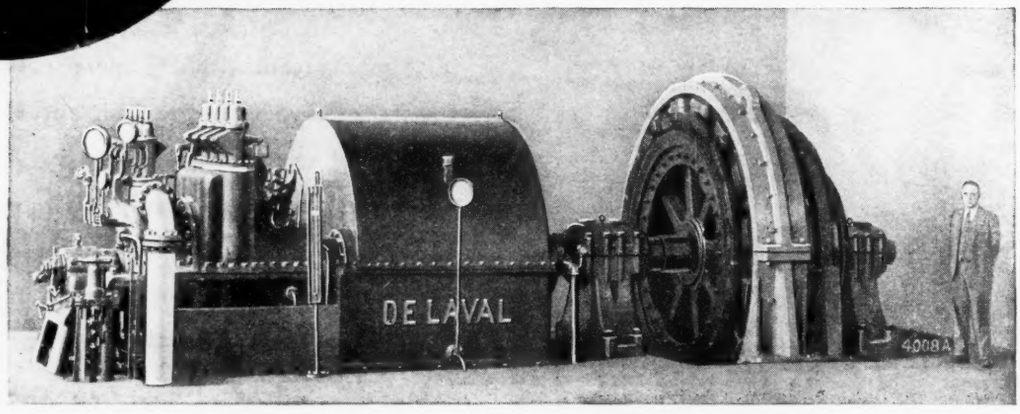

De Laval 4500 r.p.m. extraction turbine geared to 375 r. p. m., 2500 kw., D. C. generator for chemical manufacturing plant.

IMPROVEMENTS IN BOILER ROOM DESIGN AND PRACTICE AND IN

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Our engineers will be glad to cooperate in the study of any power problem by supplying engineering data and estimates.

Improvements in steam plant performance have resulted from the ability to burn cheaper fuels at higher rates and to absorb through reduced heating surface a greater percentage of the heat developed; also from increased steam pressure, from superior feed heating cycles and from refinements in the design of turbines, which operate at higher speeds and more efficiently.

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In some cases, greatly increased power can be generated from the same amount of fuel, without displacing existing turbines, by super-imposing high pressure boiler and turbine units. In other cases, power is generated at almost no cost for fuel by installing back pressure or bleeder turbines.

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Manufacturers of Steam Turbines, Centrifugal Pumps, Propeller Pumps, Rotary Displacement Pumps, Centrifugal Blowers and Compressors, Worm Gears, Helical Speed Reducing Gears, Hydraulic Turbines, Flexible Couplings and Special Centrifugal Machinery. Sole Licensee of the Bauer-Wach Exhaust Turbine System.

POWER

A McGraw-Hill Publication—Established 1884
PHILIP W. SWAIN, *Editor*

Bond of Continents

EUROPE'S eyes are focussed on political power, but it is mechanical power that makes life go on, that gives the average citizen three square meals a day and some taste of civilized life. Moreover, mechanical power is one of the great healing agents in a world whose peaceful activities are so often under the shadow of War.

Many of these war clouds are the condensation of economic dissatisfaction, of the feeling that a realignment of political power and territory will somehow increase a nation's share of the world's consumption. But at what a cost! Too often the fact is overlooked that the wastage of war reduces the amount to be shared and makes millions of men and women forever incapable of sharing anything.

The increased generation and application of power within a nation is a far safer road to prosperity—a sure way for a country to add to its own wealth without subtracting from that of others. And sound power ideas, shipped across national boundaries, bless both giver and receiver. Without tariff and often without price, they move from one nation to another and back again, changing form, continually improving, starting new chains of prosperity wherever they touch.

Engineers the world over have long recognized their common stake in the promotion of sound power thinking everywhere. Go today to any civilized country, and her engineers will meet you freely, show you their best machines, give you benefit of their best thinking. They will meet you in the friendly spirit that is natural to minds similarly attuned to the rational solution of practical scientific problems. Every good engineer, everywhere, has something in common with every other, and they recognize it instinctively when they meet. Power, then, is an international force for good in three phases: power itself, power ideas, and power men.

I feel the internationality of power particularly now because I have just returned from a tour of six European countries that kept me away from these shores for seven weeks. I come back to the American job full of enthusiasm for the things I have seen and the men I have met. Europe is doing much pioneer work, which American engineers should know about and adapt to their own needs, just as Europe adapts ours. We will have still another chance for open-minded exchange of ideas at the World Power Conference in Washington next September.

To convey to you some idea of the power developments in Europe, some entirely new to us, some outgrowths of American pioneering, we have deliberately made this number of *Power* international in character and in scope. The first installment of my "Rambles," beginning on page 244, gives impressions of power engineering in Germany, and will be followed in later numbers by rambles through the other countries. Page 255 describes the power plant of England's *"Queen Mary"* highest-powered ship in the world, whose 200,000-hp. engines will drive her here on her maiden voyage in June. Page 258 describes the Rupamotor, that German offspring of the diesel which will produce power from almost anything from potato peelings to coal dust. And pages 270 and 271 sum up my most vivid impressions of the six countries I visited.

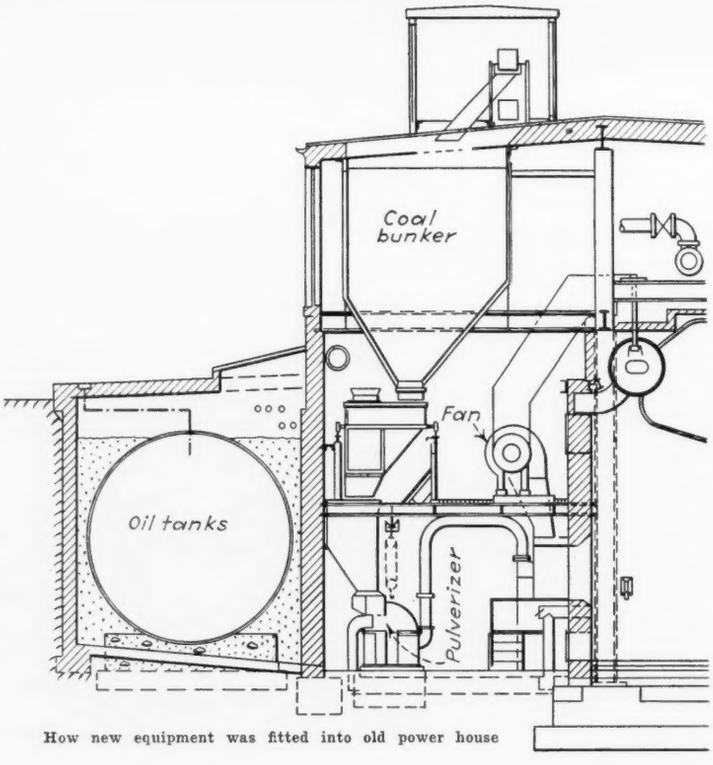
Such glimpses give us a new slant on the old world and the men whose work keeps it going. Everywhere in Europe are engineers we should be proud to know and to call our friends. In fact, peoples as a whole, not merely engineers, command one's respect in every European country I have visited. The world, as far as I have seen it, is made up largely of people who are naturally decent, honest and generous. I say this in spite of the strange things that nations do. Nations are one thing; people are another.

Philip Swain
Editor

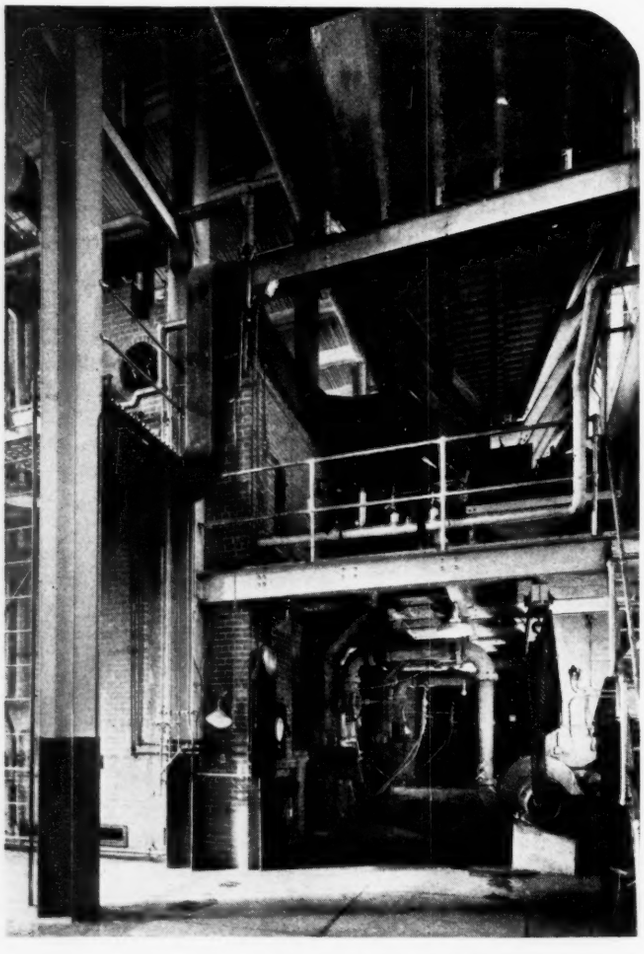
30% More Steam With 4% More Fuel

Boston State Hospital modernizes its central plant, and saves $3,000 in five weeks

By C. W. Kimball
Richard D. Kimball Co.



How new equipment was fitted into old power house

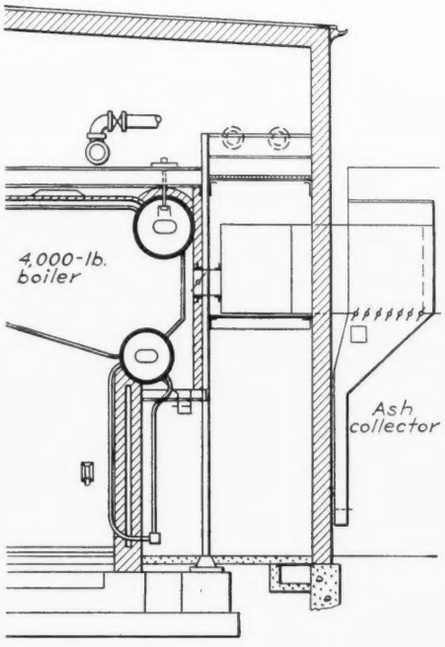


Boiler aisle showing oil burners withdrawn

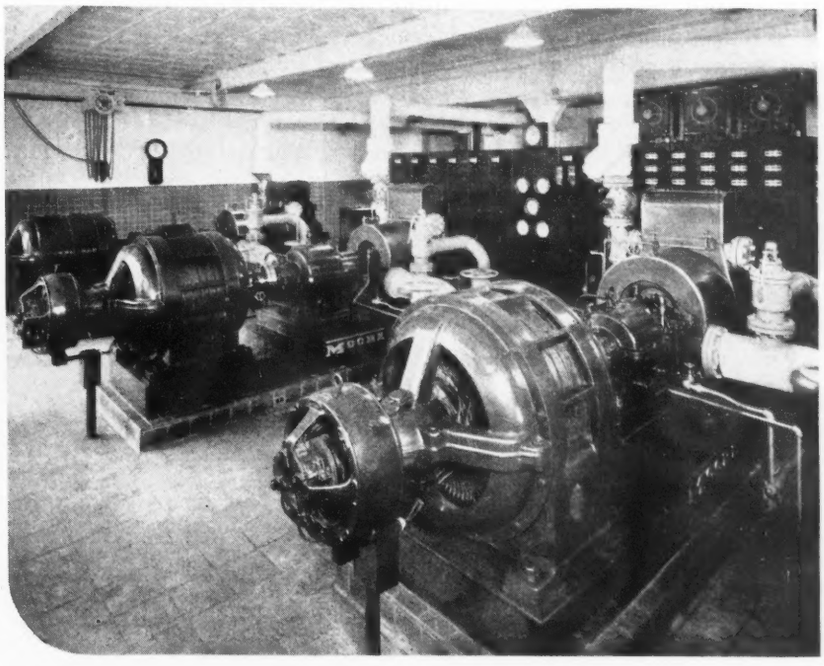
BOSTON State Hospital, one of the largest in Massachusetts, with a population of 2,500 patients and about 500 employees, has a central plant that furnishes steam, electricity, hot water and refrigeration to the 50 buildings that comprise it. Steam is supplied to approximately 300,000 sq.ft. of radiation through about 20,000 ft. of steam main. Steam for heating the east group of buildings is delivered at 4 to 8 lb. pressure, and to the west group, due to the distance from the plant, at 35 to 50 lb. pressure.

The old boiler plant included 8 h.r.t. boilers with hand stokers having a total heating surface of 16,000 sq.ft., and operating at 90 lb. pressure. The inspector required a reduction of pressure in the old boilers, and load had reached the limit of plant steaming capacity. Power was generated by two 110-volt engine-driven d.c. generators for the east group of buildings, where the power plant is located, and two engine-driven 2300-volt a.c. generators for the west group. The generating plant was also old and overloaded, so that service had to be curtailed to some extent during winter months.

The old power house, with slight changes, was adequate to house new equipment. It was, therefore, decided to remove one or more of the old units at a time to allow installation of new boilers, pumps, and generators. Planning of course had to consider fuel to be used and ways to utilize all steam used by the generating plant the year round, without making first cost prohibitive. Steam and electric generating units were figured and selected to secure units properly proportioned to operate at as high efficiencies as practicable over the range of loads experienced throughout the year. Records



Exhaust from these back-pressure turbines is utilized the year 'round



showed that during the winter steam output averaged approximately 1,250,000 lb. per day, during the summer 250,000 lb. per day.

Four International Engineering Works bent-tube 3-drum boilers, designed to operate at 200 to 250 lb. pressure, without superheat, were set in two batteries in the old boiler plant. Each boiler has 4,000 sq.ft. of heating surface, plus approximately 200 sq.ft. in the water walls at the rear of the furnace. The two upper drums are 48 in. in diameter and the lower drum 42 in. in diameter. Both drums are 10 ft. 6 in. long, the front steam drum being set 19 ft. $3\frac{1}{2}$ in. above the floor. All tubes are $3\frac{1}{4}$ in. in diameter. Both tubes and drums were protected internally with Apexior. The boilers have larger steam drums than standard boilers of this size, but experience has shown these larger drums give more steam releasing surface, more water storage and freedom from rapid fluctuation of water level.

Furnaces have an average height of 13 ft. 6 in. and a volume of 1,913 cu.ft. Suspended-type settings, using $11\frac{1}{2}$ in. Bigelow-Liptak blocks are arranged with 6-in. air space all around and 4-in. outside brick curtain walls. Air is admitted at the bottom of the setting and drawn from the top of the air space through ducts to forced-draft fans, each delivering 10,000 c.f.m. of heated air to the furnace. Fans are driven by $7\frac{1}{2}$-hp. motors, and settings are designed so that either oil or pulverized coal can be used.

Draft is provided by 7-ft. diam. 150-ft. chimney. Two expanded chambers and hoppers have been placed in the breeching to the stack to trap soot and fly ash.

Coal is delivered by trucks to a covered pocket holding about 600 tons. From this pocket it is elevated by a combination bucket elevator and scraper conveyor to two 60-ton overhead hoppers in front of and above the boilers. Coal flows from the bunkers through gates to Richardson automatic scales that record the weight of coal used, and on down to smaller hoppers that feed Riley pulverizers through magnetic separators, which remove steel and iron before reaching the mill. Pulverized coal is blown through 8-in. pipe to a turbulent-type forced-draft burner 6 ft. 6 in. up from the floor and in the center of the front wall of each boiler. An oil burner in the center of each coal burner may be used to ignite the pulverized coal or to carry the boiler load. When not in use the oil burner is withdrawn from the furnace, although left in readiness for use.

A platform above the burners carries one forced-draft fan per boiler which delivers hot air downward into the burner. Hot air to assist in drying the coal before leaving the mills is taken from low down in the furnace.

When bunker C oil is used as a fuel it is drawn by duplex steam-driven pumps from one of three 33,000-gal. steel storage tanks installed in the old coal pocket. It is filtered and forced through oil heaters and meters to the single-gun type oil burner, which is equipped with a removable tip that can be changed for varying load conditions. The furnaces are heated thoroughly with the oil burners before pulverized coal is ignited, and the oil burners are available in case there is any interruption of the coal stream.

Forced-draft equipment is used to develop high ratings, the boiler units being designed for operation

without loss of efficiency up to 250% rating. Natural draft is used for lighter summer loads by shutting down the fans and opening dampers for direct air inlet. It is interesting to note, however, that inlet air flow is strong enough through the ducts and fans to move the fan wheels quite rapidly with the motors shut down. When using pulverized coal as fuel, as high as 45,000 lb. steam per hour has been generated, per boiler without forcing or reaching the limit of capacity.

Boiler instruments include Bailey boiler meters having steam flow, air-flow and stack-temperature recorders, multi-pointer draft gages, CO_2 recorders and indicating and recording pressure gages.

From the main steam headers over the boilers steam flows to the prime movers, and auxiliaries and through reducing valves to underground mains to heat all buildings, furnish hot water, do the cooking, laundering, and sterilizing. Exhaust steam from the auxiliaries and turbines is also piped to these low-pressure underground mains. All piping is wrought iron with welded joints, except at valves where flanges are used.

Three New Turbines

The new generating plant includes three Moore horizontal turbines operating at 3,600 r.p.m. and geared to General Electric 2300-volt, 3-phase, 60-cycle generators with direct-connected exciters operating at 1,200 r.p.m. The 200 and 300-kw. units are 5-stage machines arranged for exhaust pressures up to 60 lb. They exhaust to the underground mains that connect with the west group of buildings. The 400-kw. unit is a 9-stage machine arranged to exhaust at 5 to 10 lb. pressure, into the low-pressure main to the east group. The 60-lb. exhaust main is cross-connected to the 10-lb. main through a relief valve so that any excess 60-lb. steam can flow to the low-pressure exhaust. Pumps and auxiliaries exhaust to the low-pressure main.

This arrangement has operated one full year and practically no exhaust is wasted to the atmosphere during either summer or winter. This reduces the generation of electricity and operation of the pumping equipment almost to the equivalent of reducing valves, and decreases operating cost to a minimum.

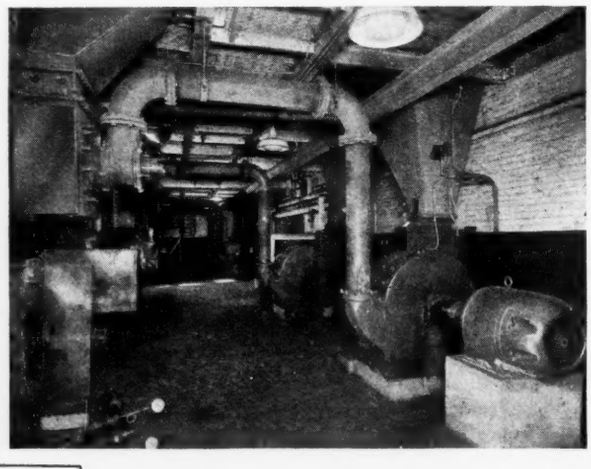
The switchboard has twelve panels, three for generator controls, one panel for exciters, one for automatic voltage regulator and meters, one for steam and water gages, and six for control of various circuits.

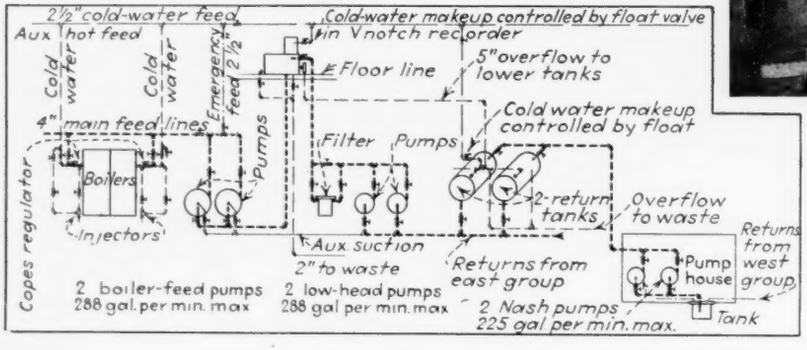
Condensate from the heating system is collected in two 5 x 8-ft. receivers in the pump room where duplicate low-head Whiton 40-hp. turbine-driven Warren centrifugal pumps elevate the water to a combined deaerating heater, storage tank and V-notch recorder made by the Harrison Safety Boiler Works. Make-up water is admitted to the heater through a 2½-in.-float-operated valve and a 5-in. overflow trap is piped from the heater to the condensate receivers below. An electric alarm is provided to warn when low water occurs.

The combined heater and storage tank is supplied with exhaust steam through a 12-in. main and will heat 100,000 lb. of water per hour to 230 to 235 deg. The storage part of the heater has a capacity of 750 gal.

Duplicate Warren centrifugal feed pumps take their suction from the deaerating feedwater heater. They are driven by 100-hp. Whiton turbines equipped with constant speed, overspeed and excess pressure governor to control the delivery of water to the boilers. Duplicate, extra heavy brass feed lines, with welded joints, are provided to prevent any interruption to boiler feed service. The piping is arranged so that the boiler-feed pumps can also draw water from the lower return tank in case the deaerating heater is out of service. Water level is controlled by Copes regulators at each boiler. To further insure continuity of feedwater, each boiler has a 2-in. Hancock injector supplied with water from the city mains.

During the first five weeks of 1936 the plant has had an output of 39,218,600 lb. of steam, using the equivalent of 1,581.81 gross tons of coal. This is 30% more steam than was used for the same five weeks of last year, but required only 4% more fuel. Operating efficiency of the new boilers was approximately 83%. Steam output averaged 1,120,000 lb. per day with hourly peaks as high as 80,000 lb. There was a saving of labor in the boiler room during this 5-week period over previous years of $359. The saving based on an equal amount of steam output was $2,388, and the excess of degree days would mean a further saving of $360, or a total saving for the five weeks of $3,107.





Left—Heat balance diagram. Above—Pulverizers are on the boiler room floor opposite each boiler

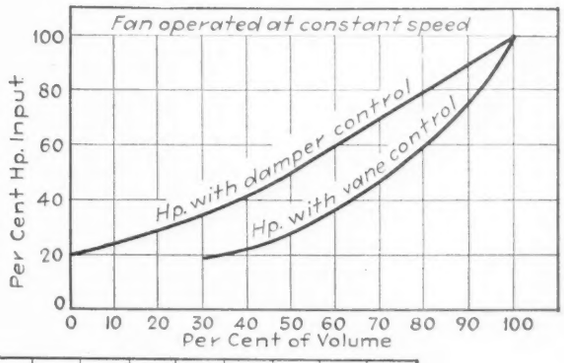
Constant Fan Speed But Variable Output

By H. D. James
Consulting Engineer
Pittsburgh, Pa.

MANY fan applications require that air volume be adjusted to meet changes in operating conditions. This can be accomplished easily with d.c. motors by controlling the shunt-field current if the speed range is not too great. The power supply, however, is usually a.c., which complicates the problem. Induction motors inherently operate at fixed speeds, depending upon the number of poles for which they are wound. A change in the number of poles gives another fixed speed without intermediate steps, which often doesn't meet the requirements.

Solution of this problem can be made in several ways. In a previous article (March *Power*), electrical methods of speed control were discussed. Mechanical means of air-flow control will be considered when fans are driven by constant-speed motors.

Power required to drive a fan operating on a constant system varies as the cube of the speed because both volume of air delivered and pressure drop as fan speed is reduced. If the fan operates on a system that requires constant pressure, power required by the fan does not vary in any fixed relation with fan speed because the fan operates at a less efficient point as speed is increased. Thus variation in power required depends largely on the fan characteristics. These considerations have an important bearing on selecting the proper means for reducing the speed of the fan.



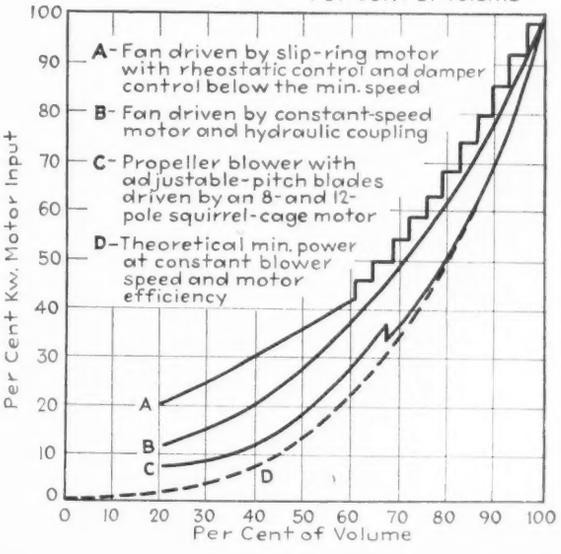
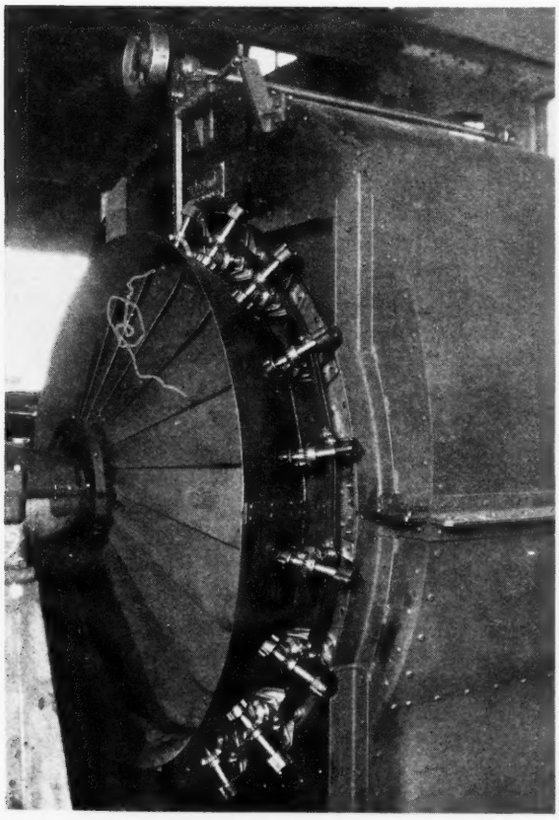

A- Fan driven by slip-ring motor with rheostatic control and damper control below the min. speed
B- Fan driven by constant-speed motor and hydraulic coupling
C- Propeller blower with adjustable-pitch blades driven by an 8- and 12-pole squirrel-cage motor
D- Theoretical min. power at constant blower speed and motor efficiency
Per Cent Kw. Motor Input
Per Cent of Volume
0 10 20 30 40 50 60 70 80 90 100

Fig. 1 (Top)—Relation between power and air volume with damper and vane control. Fig. 2 (Above)—Power and air-volume relations for different methods of volume control. These curves are typical, but may not apply to some fans

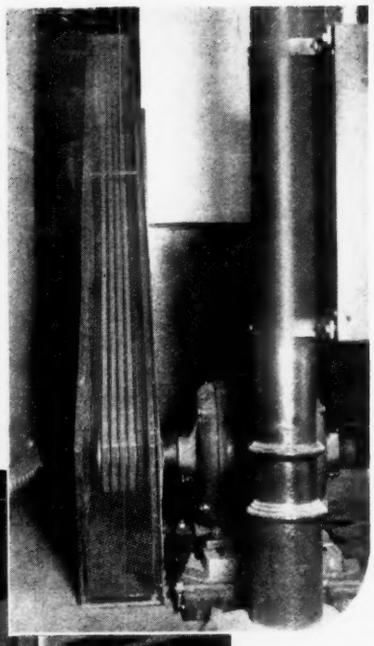
Fig. 3—Fan with vanes for air-volume control. Vanes in closed position



For combustion, the amount of air used must be regulated very closely. This is also true for various manufacturing processes. On the other hand, fans used for ventilation usually do not require close volume adjustment. The method for regulating air volume must therefore be selected to give the simplest and least expensive equipment consistent with service requirements. There are several ways in which fan output may be changed by mechanical means:

1. Use dampers or vanes to reduce output at constant speed.
2. Change pitch of fan blades.
3. Put mechanical or hydraulic speed changers between motor and fan.

Where a.c. only is available, induction or synchronous



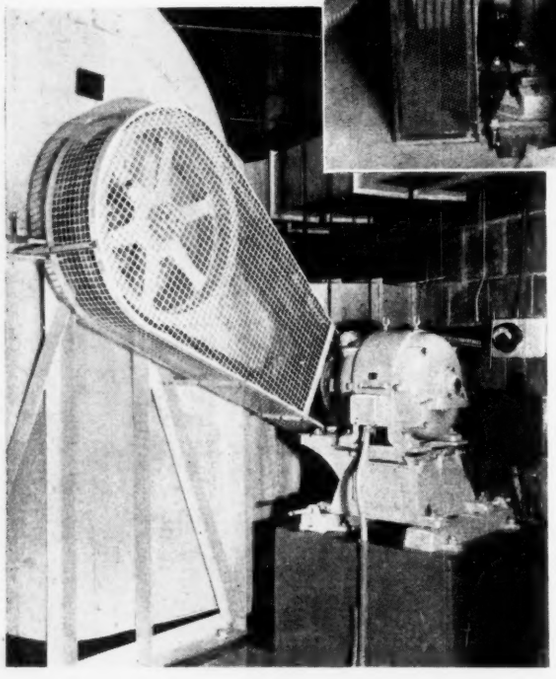


Fig. 4 (Below) — An exhaust fan driven by a 5-hp. motor at from 207 to 415 r.p.m. by a V pulley, on the motor shaft, the diameter of which can be adjusted. Fig. 5 (Right)— Blower driven by a 40-hp. motor through multiple V-belt. Speed controlled by adjustable diameter sheave on motor shaft

motors may be used for driving fans at constant speed. Small motors are always of the squirrel-cage induction type. These motors operate 2 to 5% below synchronous speed, depending upon motor load. Power factor at full load will vary with the size and the design of motor, but will be from 80 to 90% in most cases. Control is very simple. Small and medium sizes can be started by connecting directly to the line; the larger sizes generally use a reduced-voltage starter. They are usually provided with thermal relays for protection against overload, and may be started either manually or automatically from remote control.

Synchronous motors can be used on fans where the required power is 50 hp. or more. They are particularly well adapted to slow-speed fans, for their power factor can be controlled while that of slow-speed induction motors is low. Synchronous motors can have additional capacity added for power factor correction. Their control is a little more complicated than that of induction motors, but has been simplified greatly in the past few years.

When the fan is operated at slow speed, either a motor running at the same speed as the fan be directly coupled to it, or a higher-speed motor with a reduction element, such as flat belts, V-belts, chains or gears. The considerable improvement in gear drive makes it practical and often less expensive to use a high-speed motor and gearing. If pitch-line speed is kept low and the gearing properly balanced, there should be very little difficulty from noise or vibration. Fans in power houses, mines and industrial plants may be good applications for the geared motor drive.

Dampers or vanes can be used to control fan output when coupled to constant-speed motors. Performance characteristic of fans at constant speed shows decreased output with increased resistance against which the air is delivered. This pressure or resistance can be artifically increased with dampers, thus causing the fan to work farther down on its delivery curve. Dampers are usually placed on the suction side of the fan and provide easy means for controlling delivery. They are also often used with slip-ring induction motors, the speeds of which are varied in steps by secondary resistance. The dampers provide a fine adjustment in delivery between controller steps. Where air contains abrasive dust, increased turbulence due to throttling with dampers materially increases cutting in the fan passageway, and may be prohibitive in some applications. This cutting increases rapidly with the reduction in volume by damper control.

Fan-inlet Vanes

Fan-inlet vanes instead of dampers to control air flow give entering air an initial spin in the direction of rotation of the fan to decrease the relative speed between fan wheel and entering air. These vanes can be adjusted to change output volume over a wide range. This method is more efficient than the use of dampers, as shown in Fig. 1. It also materially reduces cutting of fan parts when there is abrasive dust in the air. Power input to this type of fan approaches that for one without inlet vanes using a secondary-resistance, speed-controlled, induction motor.

Pressure and volume of air delivered by propeller-blade fans can be varied by changing their blade pitch. A well-designed propeller fan operates at a relatively high efficiency over a considerable range of output by varying its blade pitch. Recently, considerable success has been attained in the development of an adjustable-pitch airplane propeller. Curve *C*, Fig. 2, was taken from tests on a large propeller blower driven by a 2-speed motor used for ventilating a machine. The actual power used is very close to the theoretical minimum. This type of fan has had very little commercial application thus far due to the expense and complication required to make the blades adjustable. Small fans used to ventilate restaurants, etc., sometimes have means for adjusting blade pitch when the fan is not running.

Several types of speed-changing devices have been developed: One comprises a V-shaped belt or chain on two V-pulleys, the pitch diameter of which may be adjusted to provide a speed range as high as 16 to 1. A special attachment makes this type reversible. When two V-pulleys are used, their diameters can be automatically controlled in inverse ratio, one being decreased when

the other is increased so that the length of the belt or chain remains constant between fixed centers while speed ratio is varied. Belt type depends upon friction, and some slippage occurs. The chain type is a positive drive. Both require the fan shaft and the motor shaft to be on different centers which, however, may be relatively close together, depending upon the type of speed changer used. A small motor or other automatic means can be used for changing the diameter of the V-pulleys, and in this way the drive can be connected to any suitable system of fan control.

Another type of this drive, Fig. 5, uses but one V-pulley, which is placed on the motor. This unit requires adjustment of motor position, as the diameter of the pulley is changed to maintain proper belt tension. The speed range is limited to about 25% of that with equipment using two V-pulleys, and speed control is usually limited to manual adjustment. It is low in cost, however, and for many applications provides an economical and satisfactory means of speed adjustment.

Multiple V-belts, until recently constant-speed drives, can now be had for speed changing by using adjustable-diameter sheaves. These equipments are available in two types: one requiring shutting down the motor to change speed, the other providing speed adjustment while the fan is running. Even when a fan is to operate at constant speed, such a sheave provides a simple and inexpensive means of adjusting speed to actual requirements, which may be difficult to predict before installation.

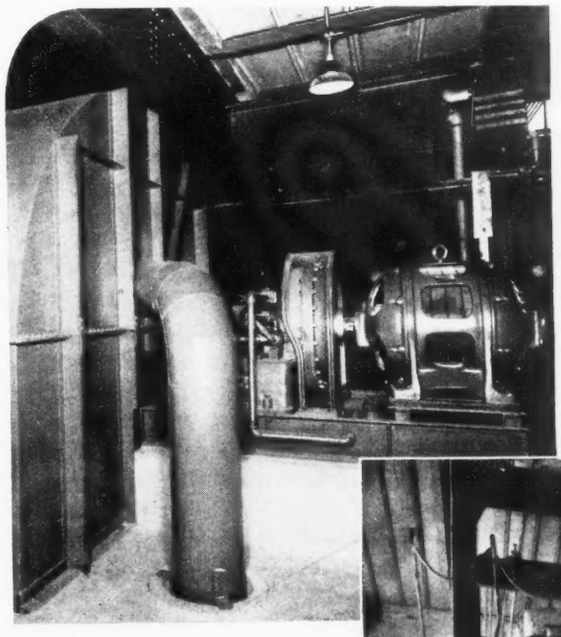
There are two hydraulic types of adjustable-speed drives. One combines a variable-displacement pump and a constant-displacement motor. This is a positive unit and will give constant output for a given setting of the control, if input speed remains constant, irrespective of load.

The other type, hydraulic couplings, is particularly suited to loads such as fans or pumps and is used extensively for these services. There is no mechanical connection between input and output elements. The input part of the coupling acts as a pump to deliver fluid to the driven part, which performs as a waterwheel to drive the output shaft. Oil is the driving fluid and is circulated continuously through the coupling. Speed regulation is by slip between input and output elements and is regulated by control of the amount of oil flowing to the coupling. When the coupling is full of oil, the difference between input and output speed is less than 3%. When the coupling is nearly empty, its output half will rotate at about 20% of input speed when driving a fan.

Since a hydraulic coupling depends on slip for a speed change, its efficiency varies inversely as the slip. On fans and pumps the power saving when operating at reduced speeds, due to reduced load on the driving unit, greatly outweighs any loss caused by reduced efficiency. Curve *B*, Fig. 2, is for a hydraulic coupling driving a fan. Its power input is less than for a wound-rotor motor, Curve *A*.

Other types of speed-changing devices include planetary double-conical-shaped rollers running in an adjustable race so that the rollers may be run on different diameters, planetary conical rollers operating within a ring, the position of which is adjustable axially along the rollers, tilting-disk rollers running in concave circular driving and driven raceways, and special devices such as variable-throw eccentrics and constant throw-clutches and other mechanical movements including sliding links and gears. Most of these devices have not been used to any extent on fan applications.

Information for this article was supplied by the B. F. Sturtevant Co., Reeves Pulley Co., Allis-Chalmers Mfg. Co., Westinghouse Elec. & Mfg. Co., U. S. Elec. Mfg. Co., and American Blower Corp.



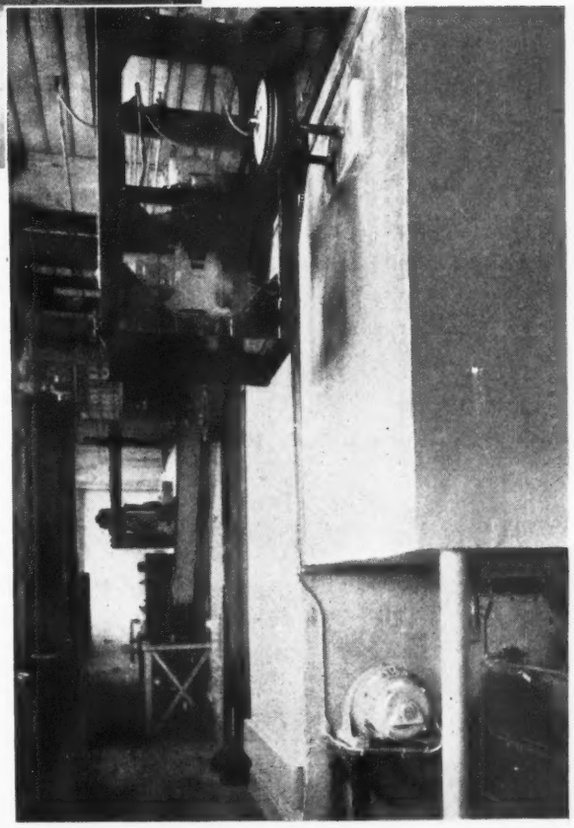
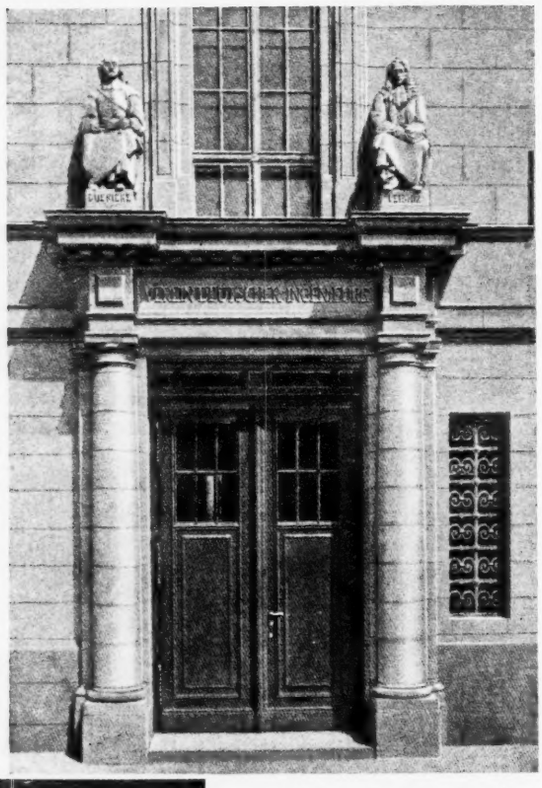


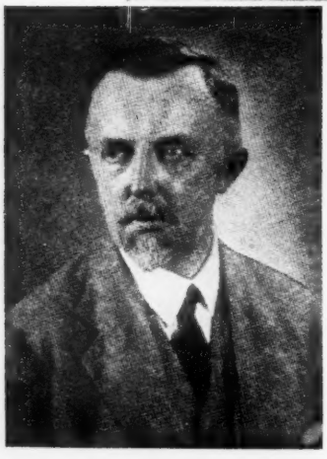
Fig. 6 (Left)—Induced-draft fan driven by constant-speed induction motor through hydraulic coupling for speed control. Fig. 7 (Below)—A 40-hp. constant-speed motor connected to frosted-wool process fan by variable-speed transmission to give a 150 to 600 r.p.m. speed range

RAMBLES

By Philip W. Swain,

Editor of POWER





Above — Berlin's "Ingenieurhaus" is home of the V.D.I., world's largest engineering society, which will celebrate its 80th Anniversary this month. Left—Prof. Dr. Ing. Matschoss, of V.D.I., is chairman of Germany's World Power Conference Committee

IT ALL started when I accepted an invitation to visit the Leipzig Fair (Page 214, April *Power*). Why not, thought I, extend the tour to other cities, other countries, and get a rounded picture of Europe's power progress? This dream soon became the actuality that kept me abroad from Feb. 19 to April 9.

Here, and in later articles, I shall tell what I saw, heard and felt in Germany, Czechoslovakia, Austria, Switzerland, France and England. In order, these were the cities I visited: Bremen, Berlin, Leipzig, Berlin, Dresden, Prague, Moravska Ostrava, Vitkovice, Vienna, Nuremburg, Munich, Zurich, Baden (Swiss), Winterthur, Paris, Bournemouth, London, Southampton. Each of these centers is contributing its bit—often a big bit—to the technique of power production.

First came Germany, land of clean streets, clean houses, clean spoons and clean woods—a whole country brushed and curried like milady's poodle dog.

Luck was with me on the morning of my first day in Berlin, as I strolled down *"Unter den Linden"* to *"Ingenieurhaus,"* comfortable home of the *"Verein Deutscher Ingenieure"* (Society of German Engineers), just across the street from Reichstag and Tiergarten.

At V.D.I. headquarters I met my old friend, Dipl.Ing. W. Parey, managing editor of the V.D.I. Zeitschrift, then Prof.-Dr. Matschoss, chairman of the German National Committee of the World Power Conference. With them was Prof.-Dr. Ing. A. Nägel, Germany's foremost diesel expert, up from the *Technische Hochschule* in Dresden. I wish here to record by debt of hospitality to these three and to many others I met in Berlin.

Next came a taxi ride through the beautiful Tiergarten to the turbine works of the A.E.G. (Allegemeine Elektricitaetsgesellschaft). There I had a conference with Prof. E. A. Kraft, the director, following which Chief Engineer Karl Hoffmann took me through the works. Here are some of the high spots: A.E.G. had on order about 600,000 kw. of steam turbines, of which half were destined for 15 foreign countries.

Now for a bit of real news. A.E.G. is building a 1,000-hp. turbine to run at 20,000 r.p.m. It weighs 5 oz. per hp. Steam pressure is 600 to 1,200 lb., vacuum about 18 in. If you should suggest that this machine would be suitable for airplane drives, no one will deny it.

For something really compact you should see the high-speed machines designed to operate with throttle steam at 1,400 lb. and 930 deg. F., and exhaust pressures of 200 to 400 lb. You could almost put the complete turbine spindle of a 20,000-kw. unit to sleep (cornerwise) in an ordinary double bed. In the high-speed rotors all of the wheels, except sometimes a wheel or two at the end, are turned solid with the shaft—a lot of lathe work and waste metal for an alloy steel job, but neat and strong. Similar machines, many designed for byproduct power generation in German chemical plants, were being made for capacities from 1,000 to 10,000 kw. And I saw one 1,000-hp. spindle that looked like a new toy for the kiddies. Shows what a combination of high steam pressure, high backpressure and high speed will do to the size of the unit.

A.E.G. machines all its turbine blades out of solid alloy-steel bars. They test rotor forgings (both turbine and generator) for internal flaws by rotating very slowly for 24 hr., while heating up and then cooling. Imperfect forgings go out of true on this test. A gage measures this to 1/100 mm.

Leaving A.E.G., I returned to V.D.I. for an intimate luncheon at which fourteen outstanding German engineers heard Dr. Harlow F. Person of New York give a fine boost for the World Power Conference next fall. It sounded mighty attractive. Certainly some of the engineers at this luncheon will be seen in America this Fall, and I hope they get the good hand they deserve.

Those present included Messrs. Parey, Matschoss and Nägel; also Dipl.Ing. F. Zur Nedden of the German Association of Gas & Waterworks Men; Obering. Tunkel of Siemens-Schuckertwerke; Dr. Freitag, of the

OF AN ENGINEER

I—Men and Machines in Germany

German National Committee of the World Power Conference; Dr. Ing. Menge, Dr. Melchinger of the government, Dr. Ing. Köttgen, general director of Siemens-Schuckertwerke; H. B. Peirce (American) of the Berlin General Electric office; Dr. Ing. H. Schult, secretary of the V.D.I.; Dr. Ing. Gärhrs of the government; Director Tröger of the A.E.G., Dr. Ing. Stäbel, member of the Reichstag. If space permitted, I could fill the page with their complete titles, but you will have to take them on faith.

After a visit with Dr. Münzinger in the office of A.E.G. in Friedrich-Karl-Ufer, I had another pleasant taste of German hospitality, once more a luncheon at the home of the V.D.I. There again I found my good friends, Dr. Matschoss, Mr. Parey and Professor Nägel and two genial Englishmen I had met on the "*Europa*," Mr. Vaughan, manager of the *Engineer,* London, and R. W. Cooper, marine editor of the same well-known publication. Also present were Mr. Ostheim of the Austrian V.D.I. section, Mr. Wagemann of the V.D.I., and Mr. Kotthaus, of the V.D.I. manufacturing engineers' group.

Under the influence of German "gemütlichkeit," the ice was broken all around and we told Scotch and other jokes in six languages: German, English, American. German-English, English-German and American-German.

After two or three days of such pleasant contacts, I had to rush down to Leipzig to spend ten days at the Fair. Since my Leipzig Fair report has already been published, I need give here only a few sidelights on the hectic days spent in that unique city.

Looking back at it all, I almost wonder that some Leipzig cemetery has not a fresh tombstone inscribed "Here lies Phil Swain, killed by work and kindness (mostly kindness)." Day after day of work at the Fair. Night after night of banquets and entertainment. Never in my life have I seen more wholehearted hospitality or tasted better food and drink.

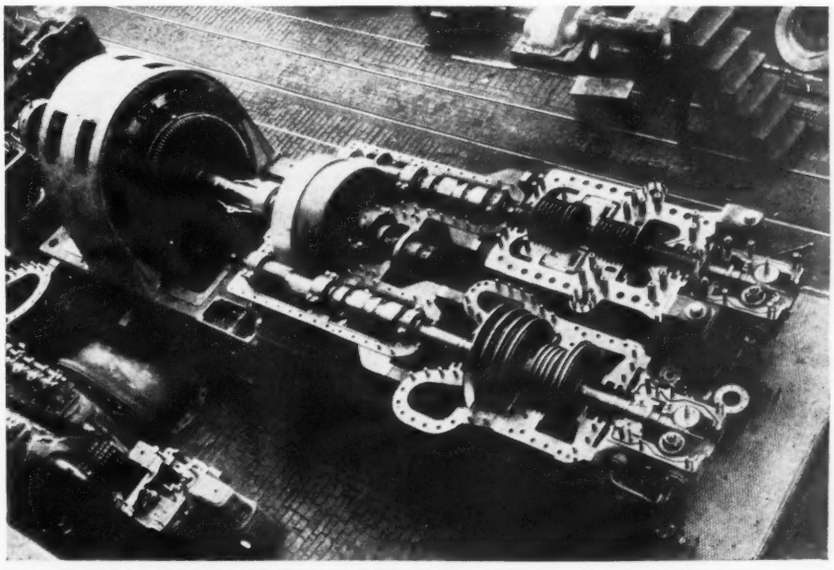
Leipzig was jammed with 250,000 buyers. Figuratively speaking, they hung by their eyebrows all over the place. Every hotel, boarding house and restaurant was full and they overflowed from the sidewalks into the road. Strict German traffic rules against jay walking were relaxed, probably on the American theory that the customer is always right. I should record special debts of unofficial hospitality to Director Schultz and Dr. Dannies, of Brown-Boveri's Leipzig office, and to U. S. Consul General Ralph Busser.

Hope springs eternal in the human breast, so I looked forward to some peace and quiet in Berlin after the pressure of work and entertainment in Leipzig. In fact, I did manage to steal a day of rest and to set thereafter a somewhat more normal pace. Yet something interesting happened every day.

On Wednesday (March 11), I joined a bus party, mainly of English and Germans, to inspect a "labor front" work camp about 20 miles out. At the age of 19 (or soon thereafter) every German boy, physically fit, must report for six months' labor with pick and shovel in one of these camps. Rich or poor, no exceptions are made. He lives in plain but neat barracks. He spades irrigation ditches, drives stakes, uses pick and shovel. On parade he wears a dress uniform and carries a highly polished shovel on the shoulder like a gun. The year of required military service comes immediately after. About 200,000 boys are now at work in the 1,300 camps. In discussing these camps, Germans stress the educational features and the effect of hard work together on the national team spirit.

I shall long remember Thursday and Friday of that week, particularly for interesting personal experiences. At V.D.I., I addressed 80 members and guests of the English-speaking circle. The talk, illustrated by lantern slides, described many recent power developments in the United States. Afterward about a dozen of us had dinner together in good German style. Friendly human contacts of this sort were the most valuable part of my trip.

Another pleasant memory is the short-wave transatlantic broadcast which I made from the "Haus von



2-cyl. A.E.G. turbine takes steam at 600 lb. and 890 deg. F., bleeds at 280 lb. and exhaust at 70 lb. Generator shaft turns at 3,000 r.p.m., turbines much faster

Rundfunk" (broadcasting studio). This gave me the opportunity to state my impressions of Berlin and of German industry and to thank those who had shown me such hospitality.

My visit to the plant of Siemens-Schuckertwerke, in the unique Berlin industrial suburb of Siemenstadt involved another experience of personal interest. But first let me set the stage by going back thirteen years to 1923. At that time one Dr. Mark Benson came to New York, took quarters at the Commodore Hotel and phoned *Power* to send a man over. I was an assistant editor at that time and I was sent.

Dr. Benson made available to me a trunkfull of data on his invention, the critical-pressure boiler, designed to produce steam without boiling at a pressure of 3,200 lb. per sq.in. My two articles in *Power* were the first published anywhere on this radical development in steam generation.

Benson Boiler Development

On March 12 I had the pleasure of standing on top of the big outdoor Benson boiler at the Gartenfeld Cable Works at Siemenstadt. The firing room is on top of this tower-like unit. Up there, 40 ft. or so in the air, I watched the operation and heard the Benson boiler pronounced a commercial success after a long period of laborious experimentation. And I sat in the Siemenstadt office with Dr. Gleichman, Prokurist, who pointed to the bald spot on his head and told me I did it," because my articles first brought the Benson boiler to his attention and led ultimately to S.S.W. taking over the patents and then to those years of hard labor.

The last six years, since 1929 when the last unit was installed at the cable works, had been different, he said. Headaches were over and things were running smoothly.

The development process has involved radical changes in operating methods. The Benson boiler is no longer ordinarily used for generation of steam at the critical pressure. On the contrary, the recommended operation is as follows: Unit speed is governed by keeping it synchronized with outside power. The feed pump is controlled solely to produce the desired amount of exhaust steam for process. Then the fire is controlled to produce whatever steam pressure (between 1,200 and 2,500 lb.) is necessary to produce the desired number of kilowatts with the existing steam flow. Valves between boiler and turbine, including governor valves on the turbine, are left wide open. Turbine exhaust goes to an evaporator which produces the process steam, so that the boiler operates on a closed circuit with distilled water.

Dr. Gleichman told me that designs were ready for another Benson unit (50 tons of steam per hour) for the cable works. Construction may start in the fall.

At the time of my inspection, the 1929 boiler was operating at 1,400 lb. pressure, delivering 27 tons of steam per hour (capacity 45 tons). The unit was fired vertically downward with pulverized Silesian coal of 12,700 B.t.u. per lb.

Steam was delivered to a 3,700-kw. turbine of new design (below), a radial-flow outfit with the high- and low-pressure cylinders at the two ends of the single generator. These radial-flow units were not of the Ljungstrom design (nested rotors turning in opposite directions). The steam flowed inward in one stage and outward in the next and there were stationary guide vanes as well as moving blades.

At the cable works, steam pressure ranges from 1,150 to 1,700 lb. Steam temperature is 840 deg. F. and back-pressure 130 lb. with bleeding at 400 to 700 lb. Turbine speed is 3,000 r.p.m.

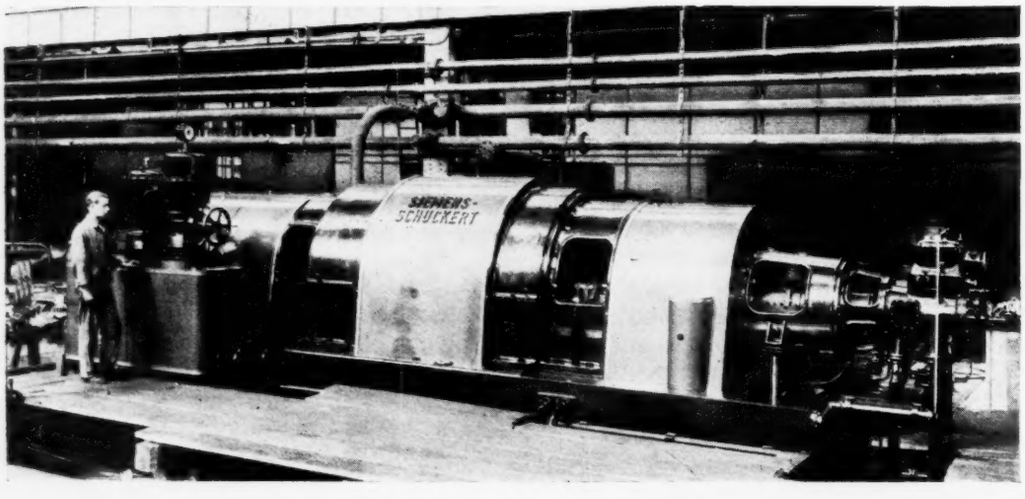
Here is a little gossip: Russia, they told me, has now standardized on the Benson type boiler and is building five units of 300-ton-per-hr. capacity. They call it the Ramsin boiler, however, because the Benson patents do not hold in Russia.

Feed-Pump Control

Dr. Gleichman showed me the interesting method of feed-pump control now being marketed by Siemens in Germany and by Weir in England. In principle it consists of two plunger pumps separately driven by induction motors and connected by an open crossover pipe. By mechanically turning the field of one or both motors, the phase relation of the plungers may be changed to produce any water delivery from zero to full load. This is accomplished without speed change or leak off.

However, Dr. Gleichman says that centrifugal pumps should be used for steam outputs above 50 tons per hour; with centrifugal pumps, the best regulation is with turbine-driven units and a turbo motor on the turbine governor.

[Because of the space required for the 40-page prime-mover special section in June, publication of the second installment of those rambles will be delayed until July. It will report the journey through Czechoslovakia and Austria and then back into Germany—EDITOR.]



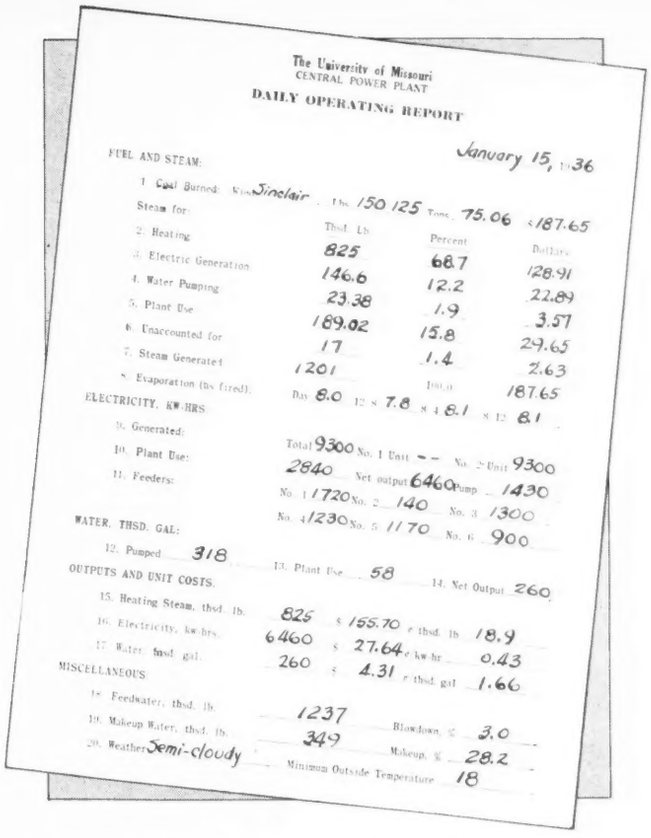
Siemens Schuckert's latest: Two radial-flow turbines at the ends of a single generator (see text)

COSTING
The Power Services

By R. H. Sogard,

Superintendent of Buildings, University of Missouri

Mr. Sogard outlines the method for determining unit costs in use at the combination heating, power and pumping plant of the University of Missouri. Cost figures in the example are approximately those of this plant



The University of Missouri
CENTRAL POWER PLANT
DAILY OPERATING REPORT

January 15, 1936

FUEL AND STEAM:

1. Coal Burned: Kind Sinclair Lbs. 150 125 Tons 75.06 $187.65

Steam for:

	Thsd. Lb.	Percent	Dollars
2. Heating	825	68.7	128.91
3. Electric Generation	146.6	12.2	22.89
4. Water Pumping	23.38	1.9	3.57
5. Plant Use	189.02	15.8	29.65
6. Unaccounted for	17	1.4	2.63
7. Steam Generated	1201	100.0	187.65

8. Evaporation (lbs fired): Day 8.0 12 N 7.8 8 A 8.1 8 12 8.1

ELECTRICITY, KW-HRS

9. Generated: Total 9300 No. 1 Unit — No. 2 Unit 9300

10. Plant Use: 2840 Net output 6460 Pump 1430

11. Feeders: No. 1 1720 No. 2 140 No. 3 1300
No. 4 1230 No. 5 1170 No. 6 900

WATER, THSD. GAL:

12. Pumped 318 13. Plant Use 58 14. Net Output 260

OUTPUTS AND UNIT COSTS.

15. Heating Steam, thsd. lb.	825	$	155.70	¢ thsd. lb	18.9
16. Electricity, kw-hrs.	6460	$	27.64	¢ kw-hr	0.43
17. Water, thsd. gal.	260	$	4.31	¢ thsd. gal	1.66

MISCELLANEOUS

18. Feedwater, thsd. lb. 1237

19. Makeup Water, thsd. lb. 349 Blowdown, % 3.0 Makeup, % 28.2

20. Weather Semi-cloudy Minimum Outside Temperature 18

MANY institutions, industries and some municipalities operate power plants that produce two or more services simultaneously, instead of being solely electric-generating or heating plants. These multiple-service plants may produce heating steam, electricity, water, refrigeration, compressed air, or hot water for heating. Fairly common is the combination plant that provides heating steam, electricity and water.

What is the net unit cost of each of these simultaneous services? Into the plant go dollars for fuel, labor, maintenance, supplies and fixed charges and out of the plant come pounds of heating steam, kilowatt-hours and gallons of water. How many dollars should be charged to the heating steam, how many to electricity, and how many to water?

The true unit cost of each service is desirable to: (1) Compare present unit costs with those in a previous similar period, to see if any improvement has been made. Or, if the results are poorer, to determine why and what is necessary for correction. (2) Make proper charges to departments, or customers. (3) Be sure that the most economical course is being pursued in self-production of these services or whether their partial or complete purchase would be cheaper.

In general, costs in a combination plant may be considered in these two classes:

1. Costs that obviously are chargeable to a particular service, such as maintenance of turbine-generators, chargeable only to electric service.

2. Costs that are general and chargeable to all three services, and thus must be divided in proper proportion. An example of this is fuel, as the steam produced from it is not only for heating, but also for power and water pumping.

It is in division of general costs that differences of opinion will occur. As a matter of fact, cost division should be made only in what seems to be a reasonable and logical way, being as accurate as is feasible without becoming too involved.

Operating costs of a steam plant may be placed in five classes: 1. Fuel, 2. Labor (operating), 3. Maintenance, 4. Supplies, 5. Fixed Charges. Whether to include the last is a matter to be settled by the accounting policy of the organization owning and operating the power plant.

Two requirements of accurate unit cost determination are (1) complete metering of outputs and plant uses of steam, electricity and water; (2) correct recording and division of labor and material charges.

Of the five classes of operating costs in the preceding list, fuel cost presents the most interesting problem of division. In an actual plant it depends upon the steam-using equipment in that plant. In the combination heating, electric and water pumping plant to be discussed, it will be:

1. Heating steam direct to steam distribution system.

2. Condensing turbine-generator units, with extraction for feedwater heating.

3. Electric-driven deep-well pumps delivering water to a reservoir, with electric-driven surface pumps delivering water to the mains.

4. Regularly used plant auxiliaries (circulating and condensate pumps, boiler-feed pumps, stoker drives, fan drives, coal and ash handling equipment, small pumps, etc.) all electrically driven, with spare steam driven auxiliaries for vital units.

All fuel burned goes, of course, into steam for one use or another. Since division of the fuel cost must be made on some common basis, it is convenient to divide all of

the steam generated and assign it to its respective uses. Once proper division of total steam generated is made, the various amounts of steam can be readily converted into dollars, and unit fuel costs found for each service.

Steam generated in the above plant will be used in the following manner:

1. Steam for heating (to distribution system)	...%
2. Steam for electric generation (to turbines)	...%
3. Steam for water pumping (pump electricity converted back to steam)	...%
4. Steam for general plant use (feed heating, auxiliary drives, soot-blowing, etc.)	...%
5. Steam unaccounted for (condensation, leakage, etc.)	...%
6. Steam generated	100%

To correctly determine net steam chargeable to each of the three utilities, the plant-use electricity, plant-use steam and plant-use water must be correctly apportioned among the three, in addition to the steam used directly. This apportionment of plant consumption of the various services is:

1. Plant Electric Use—
   a. Electricity for condenser circulating and condensate pumps should be charged to the electric utility.
   b. Electricity for deep well and surface pumps should be charged to the water utility.
   c. Electricity for boiler-feed pumps, stoker drives, fans, station lighting, coal and ash handling and other auxiliaries connected with the total steam generation should be charged to "general plant use," which is later allotted among the three utilities according to the proportion of the total steam each used.
2. Plant Steam Use—
   a. Steam for turbine auxiliaries should be charged to the electric utility.
   b. Steam for standby service water pumps should be charged to the water utility.
   c. Steam for feedwater heating, sootblowing, boiler-feed pumps, stoker engines, station heating, and other auxiliaries connected with the total steam generation should be charged to "general plant use," as described above.
3. Plant Water Use—
   a. Water for boiler-feed makeup is the principal plant use of water. For practical purposes, all water used in the plant may be charged to "general plant use."

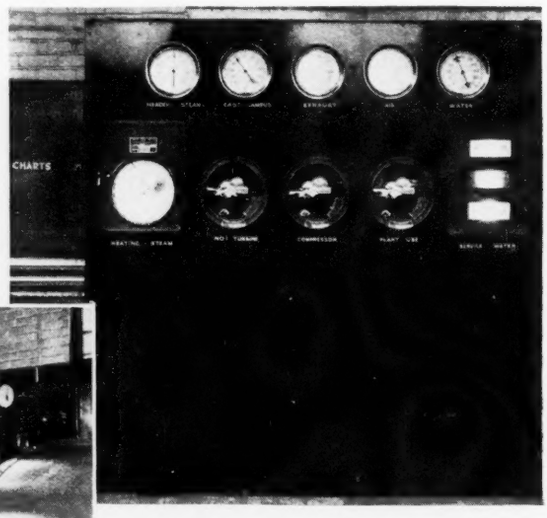
All plant use, whether electric, steam or water, represents so much energy used. Therefore all plant use must be reduced to the same energy basis, which is pounds of steam—as previously mentioned. That is, all kilowatt-hours of plant-use electricity are converted back to pounds of steam, as are all gallons of plant-use water. With all energy in terms of steam, division is simple.

Actual division of the total steam generated is then made along the following lines:

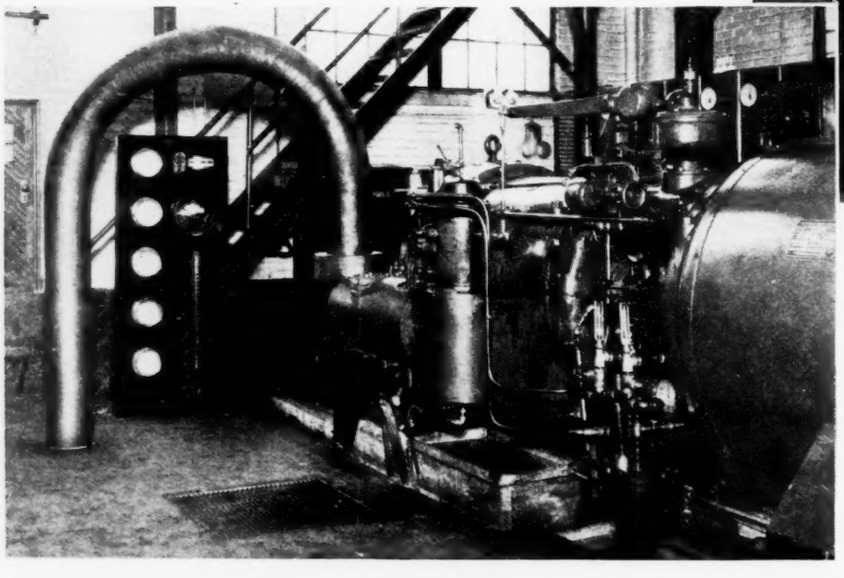
1. *Steam for Heating:* From meter readings on the steam distribution lines leaving the plant.

2. *Steam for Electric Generation:* From a throttle flowmeter, the steam input to the turbine is found. By an extraction flowmeter (with a pressure pen), total heat output from the extraction point may be determined and converted back into pounds of throttle steam. Subtracting extraction steam from throttle steam (both on the same heat basis) gives gross steam for electric generation. (It is important that steam for steam-jet air pumps, standby circulating pumps, etc., be taken off the turbine header *after* the meter orifice, so that such auxiliary steam use will be measured with the throttle steam.) Next, this gross steam is divided by the total electric generation to obtain the steam rate in lb. per kw.-hr. Then the kilowatt-hours of electricity used by the water utility and all other plant-use electricity, except that for turbine auxiliaries, is converted back to steam and subtracted from the gross steam above. The result is net steam for electric generation.

3. *Steam for Water Pumping:* Total electricity used by the water utility is converted to equivalent steam. The amount of plant-use water being known, its steam equivalent is determined. This steam to pump plant-use water is then deducted from the total steam found above, giving the net steam for water pumping.



Above—Flowmeter and gage panel in turbine room of University of Missouri power plant



Left — 600-kw. turbo-generator No. 2 and its instrument board

4. *Steam for Plant Use:* All steam for general plant use should be taken off the station header at one or two points, so that such steam may be passed through one or two "plant-use" meters. This will measure steam for sootblowing, standby boiler feed and other pumps, standby stoker drives, station heating or other uses not yet charged to the three utilities. To the steam measured by the "plant-use" meter should be added all plant-electric use, other than that for strictly the electric and water utilities, converted to steam. Likewise, plant-use water converted back to steam should be added. Finally, the extraction steam (in terms of header steam) which is used for feedwater heating should be added.

5. *Steam Unaccounted for:* The difference between the above four and the steam generated, or the balance.

6. *Steam Generated:* Boiler flowmeter readings.

For several reasons, principally as a frequent economy check, fuel cost in a combination plant should be divided each day. Although this may seem too often for the above apparently involved procedure, familiarity with a standard system and use of a simple form enables rapid calculation. Take the following data for one day:

Steam Meters	**1,000 Lb.**
Heating lines	825
Turbine throttles	296
Turbine extractions (equivalent high pressure)	110
Steam (standby) service pumps	....
Plant-use meters	63
Boiler meters	1,201
Electric Meters	**Kw.-hr.**
Main generators	9,300
Turbine auxiliaries	870
Water pumping plant	1,430
All other plant electrical use	540
Net output to feeders	6,460
Water Meters	**1,000 Gal.**
Plant use	58
To system	260
Fuel	
Coal burned, tons	75.06
Total cost, dollars	187.65
Evaporation, lb. steam per lb. coal	8.0

Total steam generated will be divided between the services in the manner just described.

1. *Steam for Heating:* Since the steam distribution system is supplied through a reducing valve, steam for heating equals the heating meter readings direct, or 825,000 lb.

2. *Steam for Electric Generation:* Steam extracted from the turbines at 3 lb. pressure for open feedwater heating is metered at that pressure, and the meter reading converted to equivalent (in heat content) steam at throttle conditions. This equivalent extraction steam of 110,000 lb. is deducted from the throttle meter reading of 296,000 lb., giving 186,000 lb. gross steam for electric generation. This, divided by the generation of 9,300 kw.-hr., gives a steam rate of 20 lb. per kw.-hr. The water utility took 1,430 kw.-hr. and plant electrically driven auxiliaries other than those for the electric and water utilities took 540 kw.-hr. These two total 1,970 kw.-hr., and the equivalent steam is 39,400 lb. Deducting 39,400 from 186,000 = 146,600 lb. net steam for electric generation.

3. *Steam for Water Pumping:* Steam equivalent to 1,430 kw.-hr. for the water pumping plant is 28,600 lb. Pumping 58,000 gal. of water for plant use required 261 kw.-hr. or 5,220 lb. of equivalent steam. This deducted from the gross steam for water pumping gives 23,380 lb. net steam for water pumping.

4. *Steam for Plant Use:* This is equal to the direct steam through the plant-use steam meters of 63,000 lb., equivalent extraction steam (for feed heating) of 110,000 lb., equivalent steam for general plant electric use of 10,800 lb., equivalent steam for plant water use of 5,220 lb., or 189,020 lb.

Tabulation of the above, with the equivalent dollars for fuel, then becomes:

	Lb.	Percent	Dollars
1. Steam for heating	825,000	68.7	128.91
2. Steam for electric generation	146,600	12.2	22.89
3. Steam for water pumping	23,380	1.9	3.57
4. Steam for plant use	189,020	15.8	29.65
5. Steam unaccounted for	17,000	1.4	2.63
6. Steam generated	1,201,000	100.0	187.65

The above costs for the three utilities are, of course, gross fuel costs. To obtain net fuel costs, dollars for plant-use steam and unaccounted for steam must be absorbed by the three utilities, which is done in proportion to the net steam used by each. By adding 68.7% for heating steam, 12.2% for electric generation steam and 1.9% for water-pumping steam, the total is 82.8%. Dividing the percent for each utility by this total, there are obtained new percent distributions of 83.0% for heating, 14.7% for electricity and 2.3% for water—totaling 100%. Then the $32.28 for plant use and unaccounted for is distributed among the three utilities in these proportions. The table below gives net costs for fuel for each of the three services.

Service	Net Cost for Fuel, Dollars	Net Output	Net Unit Cost for Fuel, Cents
Heating	155.70	825,000 lb.	18.9 per 1,000 lb.
Electricity	27.64	6,460 kw.-hr.	0.43 per kw.-hr.
Water	4.31	260,000 gal.	1.66 per 1,000 gal.

While a daily check of fuel cost is desirable to reduce waste, a monthly division of costs of labor, maintenance and supplies may be sufficient.

Operating labor may be divided into these three classes:

1. Boiler-plant operation: Labor for steam generation, including firemen, helpers, coal and ash handlers and supervision.

2. Electric-plant operation: Turbine and switchboard.

3. Pumping-plant operation: Time for starting and stopping pumps, checking the reservoir, etc.

If the operating men are paid on the hourly basis, their time is easily divided by marking on daily time cards.

In the small combination plant under discussion, the operating force consists of: 3 firemen, 3 turbine and switchboard operators, 4 operating helpers, 1 relief fireman and operator, 1 coal and ash handler, 1 engineer-in-charge.

The time of this operating force is divided among the classes enumerated above as follows:

1. Boiler-plant operation: All of the time of the firemen, coal and ash handler, engineer-in-charge; part of the time of the helpers and of the relief fireman.

2. Electric-plant operation: All of the time of the turbine and switchboard operators; part of the time of the helpers and of the relief operator.

3. Pumping-plant operation: Part of the time of the helpers.

If, as is frequently the case, the plant is basically a heating plant (that is, electricity and water could be pur-

chased but not heating steam), all of the labor for boiler-plant operation should be charged to the heating utility. Even if electricity and water were purchased, it would still be necessary to have the same number of firemen, helpers, a coal and ash handler and an engineer-in-charge. Since these labor costs are occasioned by the heating plant, they should be charged to it. Actual operating time required by the pumping plant should be charged to it. Monthly costs for operating labor are:

Boiler-plant operation—heating	$1,037.40
Electric-plant operation—electric	550.40
Pumping-plant operation—water	88.00
	$1,675.80

Distribution of the total maintenance cost logically may be made along the same lines as that of the total fuel cost. That is, the electric utility will bear maintenance costs of the electric plant and a share of the maintenance of the boiler plant in proportion to the part of the total steam to electric generation. Likewise, the water utility will bear the maintenance of the pumping plant and a proportional share of boiler-plant maintenance.

Maintenance costs should be divided into boiler plant, electric plant and pumping plant. Such division requires four things: (1) a classification of all equipment and structures in the plant into boiler, electric or pumping plant; (2) hourly maintenance men charging their time according to such a classification; (3) the use of material charge slips charging all materials according to the classification; (4) daily posting of labor and material charges on three work orders or accounts, one each for boiler plant, electric plant and pumping plant.

In this plant, monthly fuel and maintenance costs are:

Fuel for heating steam	$3,984	83%
Fuel for electric generation	720	15%
Fuel for water pumping	96	2%
	$4,800	100%
Boiler-plant maintenance	$575	
Electric-plant maintenance	220	
Pumping-plant maintenance	35	
	$830	

Boiler-plant maintenance should be distributed 83% to heating; 15% to electricity and 2% to water, and then monthly maintenance charges against services:

Heating-utility maintenance	$477.25
Electric-utility maintenance	306.25
Water-utility maintenance	46.50
	$830.00

Monthly Cost For Supplies

These should be charged to boiler, electric or pumping plant according to the same classification that is used for maintenance. If supplies for the month total $250 and were used $125 for boiler plant, $75 for electric plant and $50 for pumping plant, then distribution among the three services will be:

Supplies for heating	$103.75
Supplies for electric	93.75
Supplies for water	52.50
	$250.00

Distribution of the investment cost among the three utilities should be made according to the requirements imposed by each at the time of design and construction. For example, heating service required a certain-sized boiler plant with its land, boiler house, boilers and auxiliaries, coal- and ash-handling equipment and storage. If addition of the electric generating plant required additional boilers and therefore additional boiler house and coal and ash handling facilities, then those additional requirements must be charged to electric service. Likewise, further additions to electric generating plant to carry the load caused by the pumping plant should be charged to the water service. Therefore, the distribution of investment among the three services will be:

1. Heating Utility: Land, boiler-plant and fuel-storage facilities of sufficient capacity for the heating load.

2. Electric Utility: Land, structures and equipment for the electric generating plant of a capacity required by the electric load, plus that portion of the steam-generating plant added to supply the electric-generating plant.

3. Water Utility: Land, structures and equipment for the wells, reservoir and pumping plant, plus that portion of the electric generating plant necessary to supply the pumping plant plus additional (if any) steam-generating plant for that extra portion of electric plant.

Investment in this combination plant is:

Heating Service:	
Land	$15,000
Boiler house	50,000
Boilers	90,000
Coal- and ash-handling equipment	25,000
Chimney	8,000
Auxiliaries and miscellaneous	15,000
	$203,000
Electric Utility:	
Land	$3,000
Building	15,000
Generating equipment	60,000
Auxiliaries	9,000
Switchgear	11,000
Miscellaneous	5,000
Additional boiler plant	40,000
	$143,000
Water Utility:	
Land	$10,000
Wells and deep-well pumps	25,000
Reservoir, pumphouse, surface pumps	25,000
Additional electric plant	20,000
Additional boiler plant	8,000
	$88,000

Rate to be used for fixed charges must be determined in individual cases. Rather widely varying rates are in use because of differences in interest costs, taxes, rates of depreciation and even more because of the nature and number of items included under fixed costs.

At 8% per annum, monthly fixed charges for each utility in this illustration would be:

Heating Utility	0.08 × $203,000 ÷ 12 = $1,353.33
Electric Utility	0.08 × 143,000 ÷ 12 = 953.33
Water Utility	0.08 × 88,000 ÷ 12 = 586.65

Computation of Unit Costs

	Heating	Electric	Water
Fuel	$3,984.00	$720.00	$96.00
Labor (operating)	1,037.40	550.40	88.00
Maintenance	477.25	306.25	46.50
Supplies	103.75	93.75	52.50
Total operating costs	$5,602.40	$1,670.40	$283.00
Net outputs	20,950,000 lb.	160,000 kw.-hr.	5,700,000 gal.
Unit costs—operating	26.8¢ per 1,000 lb.	1.04¢ per kw.-hr.	4.9¢ per 1,000 gal.
Fixed charges	$1,353.33	$953.33	$586.66
Unit costs—fixed charges	6.5¢ per 1,000 lb.	0.59¢ per kw.-hr.	10.3¢ per 1,000 gal.
Total unit costs	33.3¢ per 1,000 lb.	1.63¢ per kw.-hr.	15.2¢ per 1,000 gal.

Accurate knowledge of unit costs may reveal interesting facts not previously considered. It will show that in small plants fuel is often far from being the major part of the cost of operation. Good equipment in a small plant can give excellent results, causing a low unit cost for fuel only, but on adding the other costs, the total unit cost may be high.

H.P.-H.T. MATERIALS

*By J. R. Dawson**

Union Carbide & Carbon Research Labs.

ALLOYING elements found most useful in steel suitable for high-temperature, high-pressure steam equipment are chromium, molybdenum, tungsten, nickel, vanadium, manganese and silicon. Experimental work with columbium, titanium, and nitrogen indicates that chromium steels containing these elements will find extensive use. Each of these elements exerts very definite influences on the steel to which it is added, but the effect of each is modified by the presence of other elements and by the amount of carbon.

Practically all steels used at high temperatures contain chromium. Its general effect is to increase strength, hardness, oxidation and corrosion-resistance, and creep strength. Even in amounts less than 1%, chromium tends definitely to improve oxidation-resistance and creep strength. Balanced with manganese and silicon, its ultimate strength and creep strength are both good in contrast to plain carbon steel. Steels containing 0.4 to 0.6% chromium, 1.1 to 1.4% manganese and 0.6 to 0.9% silicon have a creep strength approximately 50% higher than that of carbon steel at 1,000 deg. F. Use of vanadium, molybdenum, or nickel also improves the creep strength of low-chromium steels. A 0.62% chromium steel with 0.95% manganese, 0.20% silicon, and 0.20% molybdenum also has a good creep strength at moderately high temperatures.

Turbine parts giving good service at high temperatures contain the following alloy percentages: 0.30 carbon, 3.1 nickel, 0.35 chromium, and 0.35 molybdenum. Exceptions are parts which must be especially resistant to erosion, such as 14% chromium nozzle sections and high nickel-chromium first-wheel blading.

A number of molybdenum-containing steels have been used at moderately high temperatures on account of their high creep strength; but unless chromium is present, they have no special corrosion-resistant properties.

Chrome-Moly Tubing

One plant finding it desirable to use chromium-molybdenum and chromium-nickel tubing in radiant superheaters and reheaters operates at temperatures as low as 800 to 830 deg. F. In this case there are several thousand square feet of projected tube area, and it would not be good policy to use plain carbon steel and risk losing it through long-time corrosion. As the pressure is 1,230 lb. per sq.in., strength is also a factor.

For higher temperatures, creep and corrosion considerations demand greater percentages of chromium. A 1 to 1.5% chromium steel with about 0.5% molybdenum and 1% silicon compares in creep strength with the well-known high alloy 18% chromium, 8% nickel steel at 1,000 deg. F.; but its oxidation resistance is not particularly high.

Probably no relatively low-alloy steel can be more highly recommended for general use in high-temperature steam applications than a 4 to 6% chromium steel containing molybdenum or tungsten. Having been used successfully in the oil-cracking industry, this steel should prove excellent for superheater tubes. Its creep strength is approximately double that of plain carbon steel at 1,000 deg. F., and its resistance to scaling and corrosion is much greater than that of plain carbon steel at up to at least 1,200 deg. F.

A valve body made of this alloy with 1% tungsten showed no embrittlement after 13,000 hr. of service in a 1,000-deg. plant. The addition of titanium or columbium to this metal will no doubt greatly increase its field of usefulness, because it entirely eliminates the air-hardening characteristics of this steel, and at the same time improves its resistance to corrosion.

Intermediate between the 18-8 chromium-nickel steel and the 5% chromium steel in regard to oxidation and corrosion-resistance and creep strength, a 9% chromium steel containing 1.25 to 1.75% molybdenum has recently been announced as suitable for service temperatures up to 1,250 deg. F. Seamless tubes of this metal are now in service in many oil refineries, and should be suitable for superheater tubes in steam boilers.

Add Columbium

The 17 to 20% chromium and 7 to 10% nickel low-carbon austenitic steels probably have the best combination of properties now available in commercial steels for the several high-pressure, high-temperature service conditions. Columbium or titanium is added to prevent embrittlement and corrosive action at temperatures up to 1,500 deg. F. Tungsten and silicon give it a very high creep strength, and its corrosion- and oxidation-resistance is such that it will resist scaling indefinitely at a temperature as high as 1,700 deg. F. Although piping made of this type of steel has given entirely satisfactory service in high-pressure applications at 1,100 deg. F., still the 5 and perhaps the 9% chromium alloys will probably be more generally used for some time to come on account of their relatively low cost.

Steels containing 20 to 30% chromium can be depended upon to give long service under oxidizing conditions at temperatures up to at least 2,000 deg. F. A brittleness due to coarse grain structure, which some of these steels exhibit in welds and in the adjacent metal, is not necessarily a disadvantage; for the ductility is restored at operating temperatures. It has been found that nitrogen is effective in refining the grain and improving the physical properties of these steels.

Oxy-acetylene welding is particularly adapted to fabricating these metals in power-plan installations because of the facility with which the work is done in close quarters. Superheater tubes have been fusion-welded for many years, and welded boiler drums are becoming more generally used and should result in lowering the unit cost of the steam-generating plant. The retention of ductility made possible by the addition of columbium should remain in the extensive use of 4 to 6% chromium steels in welded-end valves and also in tubing. Welding procedures have been worked out for practically all of the metals mentioned. Steel and welding-equipment makers should be consulted in special cases.

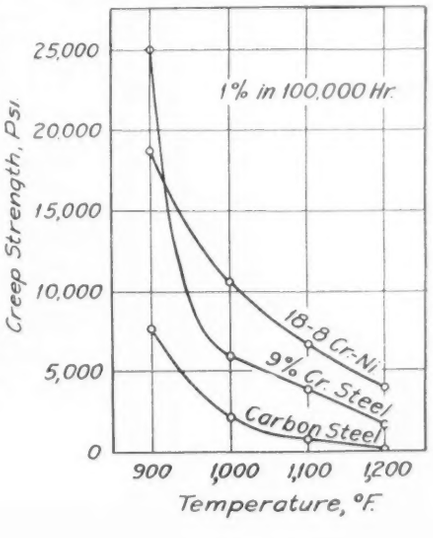
Inasmuch as low-chromium steels of the Cromansil type have a slight tendency to lose their ductility when too rapidly heated and cooled, the oxy-acetylene backhand welding method is recommended because of the more gradual heating and the fact that the backward streaming gases retard the cooling. For welding pipe walls less than ¾ in. thick, a plain steel welding rod often can be used, as it will receive a sufficient quantity of alloys from the melted base metal. For more severe service, it is frequently advisable to choose the 18% chromium, 8% nickel steel welding rods.

Welding Technique

In welding the 1% chromium steels the same general considerations apply as in welding the 5% or the 9% alloys. The main consideration is a tendency toward brittleness in the weld metal exhibited in the higher-carbon steels. This can be alleviated by annealing for about 3 min. at 1,200 to 1,400 deg. F. The oxy-acetylene process is especially advantageous for this work because, if carefully done, the flame can be used for applying the annealing heat. Columbium or titanium used in the steel preserves the ductility and eliminates the need for subsequent annealing.

Columbium is also the key metal in the successful welding of the 18% chromium, 8% nickel type of austenitic steels. Previous to the use of columbium in the welding rod and of columbium or titanium in the base metal, the regions adjacent to the weld were sometimes observed to have lost some of their resistance to corrosion. Annealing at about 1,800 deg. F. was found to restore this resistance, but this is not always practicable in the field. Various expedients, such as rapidly cooling the weld and reducing the carbon content of the steel, have been found helpful; but none are so satisfactory as the use of columbium.

Creep strengths of carbon steel, 9% chromium steel, and 18-8 chromium-nickel austenitic steel at temperatures of 900-1,200 deg. F.



*Extract of a paper presented before the Midwest Power Engrg. Conference in Chicago, April 22. The general story of the meeting appears on pages 282-283.

Forward-Curved Fans in Parallel?

In January and February POWER, M. S. Kice discussed induced-draft fans and their characteristics. Mr. Hagen and Mr. Stubinger take issue, and Mr. Kice replies

By H. F. Hagen
The B. F. Sturtevant Co.

THE February article on "Parallel Operation of Induced-Draft Fans" covers more ground than the subject would indicate and is really an attempt to justify use of the forward-curved-blade fan for induced draft. The tenor of the article is defensive. The very nature of the aerodynamic action of the forward-curved blade seems always to require this defensive attitude from any partisan who advocates the use of this type of fan for a service so exacting.

Much of the matter discussed in the article —and stated with seeming authority—is controversial, subject to the indeterminism of opinion and experience. To avoid unsatisfactory and inconclusive argument, this discussion will be confined to two important points that invite direct and exact opposition.

First of these is a practical quantitative consideration of motor input and power factor. Mr. Kice recommends a motor overpowered 50% to guard against motor overload when only one fan is in operation. One fan operating on the system is inefficient fan action. With two fans operating and with two motors selected as Mr. Kice specifies, the motors are only $\frac{2}{3}$ loaded at full plant load and are in the lower power factor and decreasing efficiency range. The average power plant operates a major portion of the time well below maximum requirements. Fan horsepower is so much reduced (approximately as the cube of the load) at the normal requirements that one of the major difficulties in mechanical-draft economics is to secure a passable compromise between overall efficiency at normal load operation and desired capacity at full output. Probably few power-plant engineers would dissent from the general statement that a satisfactory compromise has yet to be discovered. The type of fan recommended by Mr. Kice makes a bad matter worse, exaggerating as it does the discrepancy between motor rating and normal motor load. Mr. Kice has possibly been overliberal in sizing his motors. There is no objection to a reasonable overload under the emergency condition of single fan operation, but with any consistent safety factor, forward-curved-blade fans will require larger excess motor capacity, and consequently, give lower operating motor efficiencies, in the range of normal plant operation.

The second point is the subject of the article, "Parallel Operation." In Fig. 3 of the article, Mr. Kice shows a fan characteristic curve and purports to prove that two fans, each having this identical characteristic, will operate perfectly in parallel at the point *B* The reason given for the fans operating at *B* is that this point is the only one at which the requirements of parallel operation are completely met. These requirements are correctly enough implied in the article, namely, that the characteristics of both fans and that of the system shall be completely satisfied both as to static and velocity pressure requirements.

However, Mr. Kice does not analyze the problem of parallel operation at all. Because of the misconception due to his entirely erroneous "train of gears" analogy, he does not realize that his argument amounts to nothing more impressive than the statement that the fans will divide the load because he can't figure them at any other point.

The fallacy of assuming that fans must operate at a point where their outlet-velocity pressures equal the required system velocity pressure is at once made evident by his single-fan operation. The velocity pressure from the one fan at only 170% volume is $3\frac{1}{2}$ times the velocity pressure of the system at the full 200% with two fans. There is no reason why velocity pressure should be any less discriminatory with one fan than with two. It is perfectly correct that velocity pressure must be considered, but it cannot be ignored for the single fan and used to prove the argument for the two fans. Correction of Mr. Kice's single-fan discrepancy in velocity pressures is a suitable beginning for the refutation of his claim of parallel operation of such fans.

It is obvious that the high velocity at the fan outlet must slow down in the system. Dependent upon the nature of the transitional flow, there will be a greater or lesser loss in total pressure and a regain in static. There will always be some increase in static, determined by the change in areas and the efficiency of conversion. In other words, there is, between fan and system, the equivalent of an expanding chimney of an efficiency whose probable minimum is that of abrupt expansion. The effective static pressure operating on the system will be somewhat higher than the fan static. Mr. Kice's crossing point of operation of one fan may be considered as a first approximation. The conversion can be calculated for several points and a portion of the effective static pressure curve for one-fan operation drawn in. Intersection of the system characteristic with *this* curve will give the correct operation for one fan alone which, through the adjusting action of the transitional flow, satisfies completely fan action and system requirements.

It is again evident that in a thoroughly general analysis of fan paralleling, the point so found may be considered as an extreme of the action where one fan delivers all the air, and any second fan a zero volume.

Fig. 1, is a reproduction of Mr. Kice's Fig. 3 with the effective static *DD* and the new point for single-fan operation, *Y*. The pressure of point *Y* plotted at zero volume on curve *LL* may be considered as the performance of that second fan effective on the system. If this second fan is speeded up so that it develops a higher effective pressure, it will deliver some air to the system, and the volume from the first will decrease. The transitional flow now becomes complex; not all of the system area is available for the decreased flow from the first fan. A virtual expanding chimney of changing ratio exists for the first fan, and figures of static regain can be calculated for the new condition. At the same time, the second-fan delivery is crowded into a correspondingly smaller area than its outlet. Tedious trial-and-error calculations can be employed to get such intermediate points for the two fans, but for practical purposes they are hardly necessary.

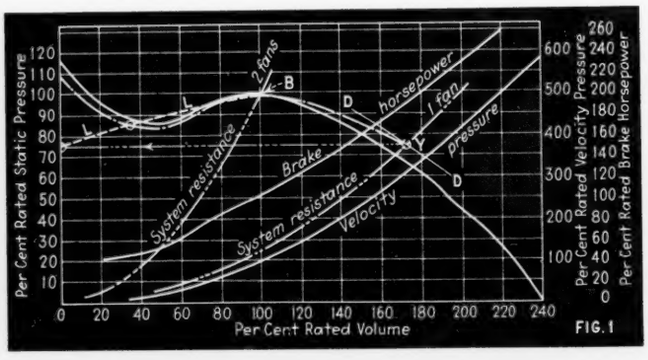
Three points on the effective curve are ready at hand. The first is the point *Y* already determined. The second point is the point of equal volumes from the two fans—Mr. Kice's point *"B"*. Mr. Kice deals with a special case with a system duct twice the area of one fan outlet, in which case, the correction at *B* is zero. Correction for the general case can be determined by figuring the conversion between fan outlet area half the area of the system duct. The correction can be positive or negative as the system area is larger or smaller than twice the fan outlet. However, Mr. Kice's special case will serve, and the second point may be taken as the fan static at *B* with zero correction. On the small-volume side of *B*, the range of performance of the possibly weaker fan, the velocity pressure is not sufficient for the system requirement and there must be a conversion of part of the fan static. The effective curve in the small-volume range is, therefore, below the fan static. At zero volume, the effective curve is below the fan static by the velocity pressure in the system, as required by the volume from the first fan operating at *Y*. Location of this third point of the corrected curve is more easily understood if a differential volume instead of a zero volume is considered.

To deliver even a differential volume to

Fig. 1 — Reproduced from Fig. 3 of February article with curve of effective static added

Fig. 2—Mr. Kice's Fig. 3, showing possible points of parallel operation

Fig. 3—Characteristic of induced-draft fan



the system, the fan must furnish the velocity pressure the system requires.

If now, the particular fan has a corrected static at zero volume above the limit pressure of *LL* selected for the before-mentioned "any fan", then that particular fan will deliver some air to the system. The determination of just how much air it will deliver and its action in parallel is best determined and and demonstrated by a comparison of the completed limit curve *LL* with the corrected or effective static.

The abscissa of the limit curve, *LL*, for any pressure in the range of the problem, is the volume difference between the system volume at that pressure and the volume of the corrected static curve beyond *B*. In other words, *LL* may be considered as the effective or corrected static of a hypothetical fan which would not operate determinately in parallel with the fan under examination but would function unstably, satisfying system and fan at any volume from zero to *B*. This limit curve can be used with the corrected curve of the second fan to show a possible operating point at every intersection. If two fans will parallel with stable operation, there will be only one such intersection.

Mr. Kice's curves for the forward-curved-blade fans are analyzed as described in Fig. 1, his Fig. 3.

There is a point of operation of one fan at 35% with the other at about 150%. The combined pressure and volume are low and the efficiency of the two fans about 20% low. Further, the limit curve agrees closely with the fan curve from 80% to 100%. Such coincidence will permit the fans to surge from 80% to 120% volume, an intolerable operating condition. The fans can parallel at *B* only in unstable equilibrium. The first point mentioned, the 35 and 150%, is the probable point of operation as the limit curve crosses the fan curve at a fairly determinate angle.

This discussion as a refutation has been obliged to meet Mr. Kice's terms. The direct application to induced draft, where most of the work is done on the suction side, may appear not clear in either the article or the discussion. The analyses are applicable, however; any changes for work done on suction or pressure sides would be minor and physical and not theoretical.

If the complication of velocity pressure had not been introduced, the analysis could have been based on static alone, which would at once have been simpler and for all practical purposes just as serviceable. When fans are connected to a large plenum, it is entirely correct to consider static only. For most induced-draft installations, an analysis of the possibility of paralleling, based on static only, gives a sufficiently accurate approximation.

In Fig. 2, the analysis is shown without the velocity conversion corrections applied to the static curves. These corrections are small at best and use of the fan static directly, leads to exactly similar conclusions, namely, that the fans will not parallel successfully. They can operate, one at *D*, the other at D^1 or at *E* or E^1, or unstabily at *B*.

There remains one more point in the discussion. Fig. 3 shows the characteristics of a typical induced-draft fan suitable and properly selected for parallel operation. The simple form of analysis has been used, as in Fig. 2. Limit *LL* curve crosses at only one point and at a determinate angle. These fans will parallel successfully.

Finally, for the sake of completeness, the statement should be made that an interchange of energy can take place under certain conditions between the air streams from the two fans due to combining momentums. It seems quite unnecessary to develop this action as it would result only in a modification of the adjusted static without effecting the theoretical analysis of altering the conclusions.

It is apparent that Mr. Kice's fans, if selected understandingly to operate, not at *B* but in the region nearer *Y*, would parallel. However, this region nearer *Y* is one of low efficiency. It seems sound to state that good efficiency with stable parallel operation cannot be secured with the forward-curved-blade fan.

By F. B. Stubinger

Buffalo Forge Co.

FROM Mr. Kice's articles, one gets the impression that the forward-curved-blade fan is as safe from power overload as the regular "non-overloading" types, and that its dipping pressure characteristic cannot cause any operating difficulties. I do not believe that Mr. Kice actually intended to convey this impression, since the experience of many users has proven the contrary.

The forward-curved blade is the older type of multi-blade fan and its suitability for certain applications is recognized by fan builders. The backward-curved-tip type has certain advantages in pressure and power characteristics not found in the old forward-curved fan, which gives more dependable performance.

Forward-curved fans will operate satisfactorily in parallel under certain maintained resistance conditions, but it is well-known among fan manufacturers and also among the more experienced users that the forward-curved-blade type is extremely sensitive to resistance changes throughout a certain portion of its capacity range; and that two or more such fans operating in parallel can become seriously unbalanced in this region.

A large user of mine fans recently told me that he tried to increase the air handled through a certain mine by operating two fans in parallel (one normally being a spare) and found that there was practically no increase in total air delivery when the second fan was in operation. They also reported that at times some of their mine fans showed a decided surge in capacity, and the consequent noise gave one the impression of standing at the seashore, hearing the surge of waves. These were all forward-curved-blade fans. Mine resistance is subject to considerable change and the troubles mentioned are due to a too-sensitive fan-pressure characteristic which could not satisfactorily meet the resistance and capacity changes.

Some years ago I saw two forward-curved-blade fans in parallel on test. The greater capacity load could easily be thrown to either of the two fans by unbalancing the resistance when these fans were operating in sensitive range of pressure.

All makes of forward-curve fans having the well-known dip in the pressure characteristic are subject to this erratic operation throughout this section of the capacity range.

By M. S. Kice, Jr.

Head, Industrial Division
American Blower Corp.

I AM not surprised that Mr. Hagen offers criticism of my two articles, and that he chooses to rest his case on mathematics.

During the last 8 yrs., I, likewise, have attempted to treat the subject this way, and have read everything available to me, where others have attempted the same thing.

There is nothing, so far, including Mr. Hagen's present treatment, that agrees with actual facts of the case.

These two POWER articles were offered as a record of just what has been learned in connection with induced-draft fans. I believe, if Mr. Hagen will make the same practical study in an unbiased manner, over an extended period of time, he will come to the same conclusions as I have, and will discontinue being satisfied with only a theoretical treatment.

One of Mr. Hagen's points covers a very special case that I mentioned, being a suggestion for that designer that wanted to balance a slightly lesser efficiency for maximum reserve capacity.

Forward-curved fans are the only fans that will carry a boiler 85% full two-fan capacity when only one fan is operating. In this most extreme case, only 92.5% of the total two-fan horsepower is required. This is a loss of only 8% from maximum efficiency at a first cost of only 50% oversize motors. Such a practical case might be a central heating boiler plant or a waste-heat boiler plant where con-

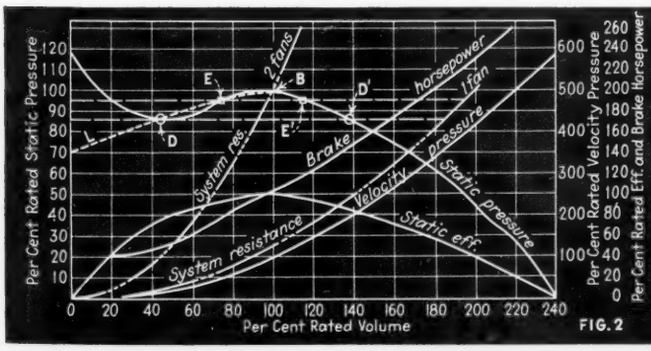


FIG. 2

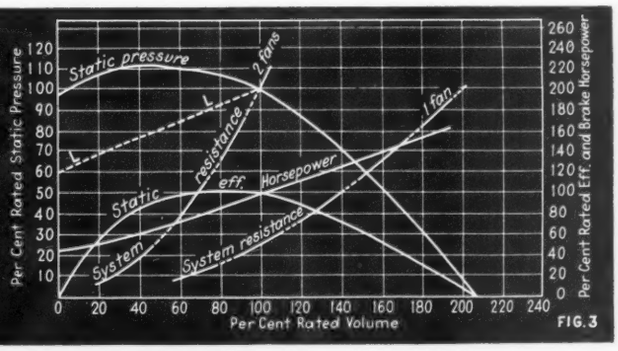


FIG. 3

tinued maximum boiler operation, with maximum fan spare capacity over an extended period, is imperative.

I trust this statement of this special case will not cause the reader to overlook the fact that for regular public utility service, two forward-curved fans, in parallel, can be, and actually are, closely motored. This was clearly stated in the article. No case is known where a driving motor has been damaged when driving a Sirocco induced-draft fan even though it is selected with no reserve power.

The essence of Mr. Hagen's second point is the statement and attempted proof that forward-curved fans will not operate in parallel when selected at the peak of either the mechanical or the static efficiency curve. Contrasted to this, I have stated that they will.

Mr. Hagen feels this is a matter of opinion, whereas I stated it as a matter of fact from experience, and trust the reader will indulge this healthy difference.

Misunderstanding

It is unfortunate Mr. Hagen went to so much detail by misunderstanding my reference to velocity pressure. His Figs. 1 and 2 are the same thing, therefore, we can waive entirely all reference to Fig. 1. Fig. 2 is much easier to handle.

Velocity pressure conversion to static pressure was not the question. Velocity pressure was offered as a fan characteristic, being as much the characteristic of a fan as horsepower, static pressure, etc. To build up his theory, Mr. Hagen has assumed that the special case, where one fan is shut down and the other is working at 169% capacity. In this case the one fan would draw through the other one, so he has assumed the idle fan is speeded up so its zero delivery static equals the static of the one fan. In the case of his curves, this is 70% static instead of the full-speed zero-delivery static of the two fans of 118%. The slower fan would operate at about 77% speed to accomplish this, that is, to maintain 70% static at no delivery.

This is not parallel operation at all, for any kind of fan.

We are talking about both fans at full speed where the zero delivery static of the second fan, or each fan, or both fans, is 118% instead of 70%.

Let us, however, mentally operate one fan at 77% speed and the other at 100% speed to try the theory.

To make the case simple, we will increase the speed of the low-speed fan until we arrive at his point D, Fig. 2.

This is not an intersection because the second fan will have a characteristic like the full-speed fan only lower down all the way across the abscissa. The zero static delivery of this second fan will lie between 70% and 118% static. Point *D* lies on the full-speed fan-static curve, the same as the other points, *E, B, E'* and *D'*. The two static pressure curves of each fan cannot intersect, regardless of what type of fan is used.

Referring to Mr. Hagen's Fig. 3, I agree that this type of fan, referred to as the "radial-tip" fan, will operate in parallel when properly designed and constructed. Most manufacturers of mechanical-draft fans, including my associates, make this fan. It is a good fan.

But, if one takes seriously Mr. Hagen's criticism of the forward-curved fan when operating at maximum efficiency in parallel, one would fear the radial-tip fan would surge, when a boiler system slags up badly and forces the two-fan operation to the peak of the radial-tip pressure curve. If two such fans are operated at 40% capacity, from such slagging, one fan operation would be at 79% capacity, 107% static. A line drawn from 107% static, no delivery, and the static at 40% capacity, intersects the fan static curve at 28% capacity hence this theory would show surging between 28% and 70% capacity. However, if these fans in question are stable, individually, they should remain stable under this condition.

May I add that I have witnessed an actual set-up and measured demonstration of forward-curved Sirocco fans in parallel. This was witnessed also by a number of independent engineers. These fans were separately motored and were served by a common chamber and the variable orifice was in this chamber, not on each individual fan. These two fans worked perfectly, independently, at identical speeds and at different speeds, and each performed on its own proper curve. They were absolutely stable across the entire range of the static efficiency peak. The interesting thing is, they were not entirely stable at a point entirely overlooked by Mr. Hagen. This was on the second rise of the pressure curve at about 20% capacity where, incidentally, Mr. Hagen's theory would prove they are stable.

Individual Dampers

In service, such fans can be forced to such a point by damper operation, but in this case individual dampers are used on each fan and hence isolate entirely each fan, hence no question arises as to surging at this point.

I and my associates have seen fans surging in parallel, and surging in single operation, in fact violent surging, but from an entirely different cause.

If any fan, and especially a forward-curved fan because of its greater kinetic amplification, is not properly proportioned as to its component parts, the result is likely to be an unstable fan. Unstable fans, in my experience, offer a hazard in parallel operation, and trouble may be expected. This would apply to any specific design where the fan shows unstable characteristics when operated singly. Incidentally, Mr. Hagen's theory does not account for this phase of fan characteristics.

The above will answer, likewise, Mr. Stubinger's criticism. The final answers to the question of forward-curved fans in parallel are the number of contracts my associates have made with large discriminating corporations guaranteeing that their forward-curved induced-draft fans will operate in parallel without surging, and they will continue to enter into such contracts. No such fans have ever had to be corrected in the field, and all have been satisfactory.

I previously pointed out that no type of fan will prevent overload from temperature reduction, which is governed by physical law and demonstrated the power required, by all types of fans, under variable load. When the fan characteristic alone is considered, it does appear the forward-curved fan is sensitive to pressure characteristics. To show what actually governs with a system, I put the forward-curved and other fans through extremely wide "paces" of drop and increase, in system resistance, and demonstrated quantitatively just what happens to the four types. The reader is invited to read the two articles, rather than to have to repeat the statements here.

The large mine user, referred to in Mr. Stubinger's criticism, has experienced the case I covered, under rising static, as stated on the last page of the February article, beginning the third paragraph under "variable load." It is apparent the mine operator did not fully understand his fan laws. He won't get double volume from any type fan in this case, but will get less from the forward-curved, and most from the high-speed backward-curved fan. The others will fall in between these limits. When one fan is originally selected for minimum horsepower and another identical fan is operated in parallel with the first fan, the total percent volume of the two fans is as follows: forward-curve 135%, radial-blade 142%, radial-tip 144%, high-speed 152%. This is the inverse of forward-capacity characteristic mentioned in reply to Mr. Hagen. The above figures are obtained by plotting a system characteristic of 200% resistance pressure, and reading the intersection with the fan-resistance pressure curves.

The percent fan capacity was doubled to get two-fan performance. Incidentally, the two-fan total horsepower, under above case, is: forward-curve 138%, radial-blade 161%, radial-tip 159%, high-speed 168%, and the horsepower per c.f.m. penalty is: forward-curve 2.2%, radial-blade 11.8%, radial-tip 9.4%, high-speed 9.6%, being the horsepower penalty for reserve capacity on rising static.

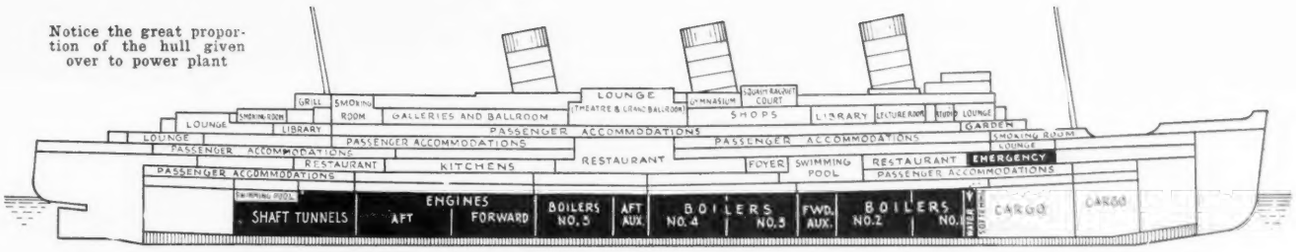
Finally Mr. Stubinger stated he saw, some years ago, two forward-curved fans, on test, that hunted. As stated in reply to Mr. Hagen I have also. This discussion as qualified at the outset of the January article covers the modern forward-curved fan. Thus may I beg to differ with Messrs. Hagen and Stubinger entirely, in light of the above reply.

POWER NOTES

SWEDEN'S total power consumption last year was 2,170,000,000 kw.hr. of which 2,150,000,000 were developed at government-owned power stations and 20,000,000 were purchased from private companies. State railways consumed 215,000,000 kw.hr. as compared to 160,000,000 in 1934.

INSPECTION of the Kamerlingh-Onnes Laboratory, the center of the studies at very low temperatures, will be included in the program of the 7th International Congress of Refrigeration to be held in Holland, June 16-27, 1936.

JAMES ROBERTSON was elected chairman of the Vancouver, B. C., branch of Engineering Institute of Canada at the annual meeting recently. Other officers elected were: H. N. McPherson, vice-chairman; T. V. Berry, secretary-treasurer, E. C. Thrupp, C. L. Tooker, P. H. Buchan, and F. O. Mills, committee. Following election of officers, J. P. Forde, chief engineer of Department of Public Works at New Westminster, gave an illustrated address.



POWER QUEEN OF THE SEAS

SOME 200,000 hp.—more than any other ship's power—will drive the *Queen Mary* across the Atlantic after she leaves Southampton May 27. Contrasting sharply with the *Normandie* in both hull design and system of propulsion, the *Queen Mary* is 20,000 hp. more powerful than the *Lexington* and *Saratoga,* 40,000 hp. more than the *Normandie.*

In test runs April 18, *Queen Mary* attained 32.84 knots, or 38 m.p.h., according to unofficial reports, and 30 and 30.4 knots on two runs officially admitted, in comparison to the 30.31 knots of the *Normandie* record crossing.

Instead of being riveted directly to the bedplates, turbine foundations are sprung and engines are cushioned by an adaptation of modern automotive practice. Instead of the *Normandie's* turbo-electric drive, *Queen Mary* has single-reduction geared turbines, provided with steam by 24 water-tube Yarrow-type boilers.

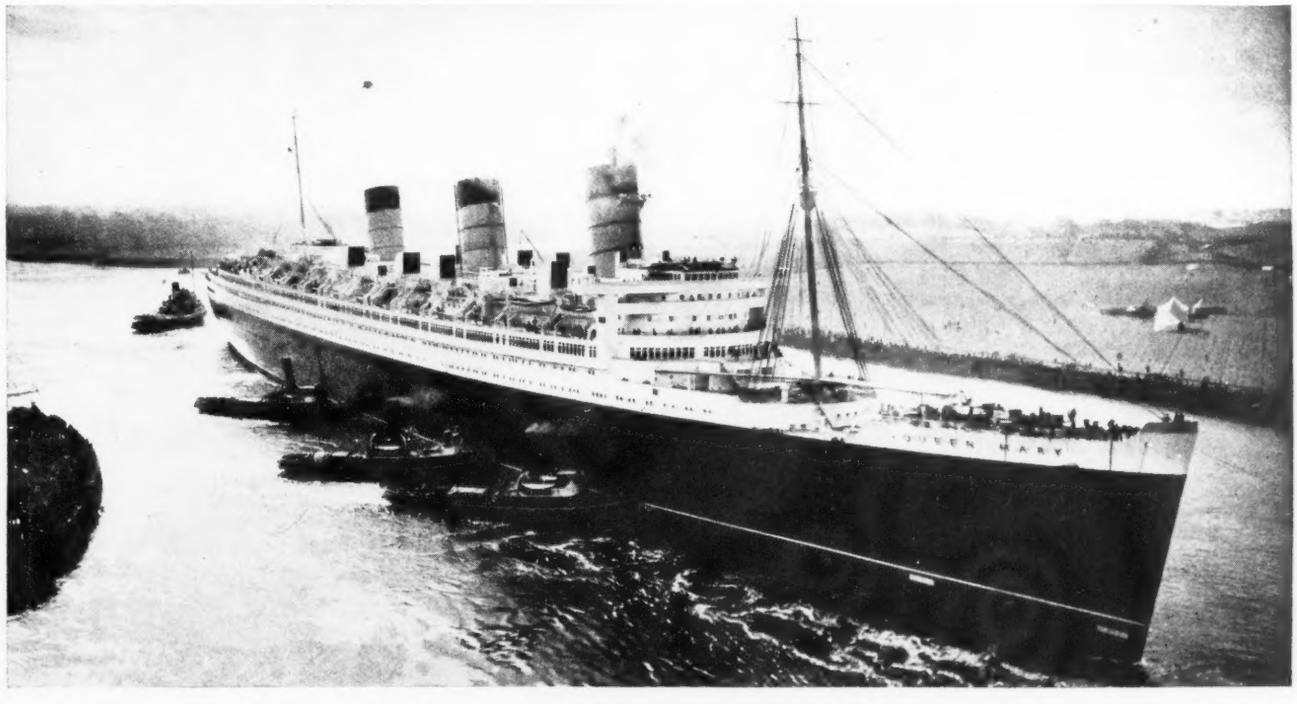
It is difficult to conceive of the size of the *Queen Mary.* She is 1,018 ft. long overall, 1,004 ft. at the waterline. Stood on end, she would reach the 86th story of the Empire State Building. She is 118 ft. wide and 180 ft. from the keel to top of funnels, will accommodate 3,500 people including crew, has twelve decks, including a 750-ft. promenade. A few other vital statistics: gross weight 80,773 tons, rudder 140 tons, 4 propellers each 35 tons and 20 ft. in diameter, anchors weigh 16 tons apiece, knife-edge bow and double-bottom hull, 2,000 portholes, 10,000-000 rivets, 20 acres of decks, 50 miles of plumbing, 21 elevators, 60,000 cu.ft. of refrigerated space, both warm and cool fresh-air supplies to each cabin, prepared in a spray-washing and dehumidifying central plant and circulated by fans.

There are five boiler rooms, two engine rooms, an auxiliary turbine room and a service turbine room. 50 side bunkers carry 6,300 tons of fuel oil, lead through 3,000 ft. of piping to the 200 burners under the boilers. Steam for propulsion is provided by 24 Yarrow water-tube boilers generating at 440 lb. and 700 deg. F., and that for services by three Scotch boilers generating at 250 lb. and 250 deg. superheat. The 160,000 boiler tubes are guarded against corrosion by a Weir closed-feed system including regenerative condensers, extraction pumps, steam-jet air ejectors, drain coolers and heaters. All makeup water goes to the condensers, which are 2-pass, well-based units with a total of 60,000 cupro-nickel tubes. Drain coolers are 4-pass and heaters 6-pass. All auxiliaries, including the 16 combustion air fans, are electric driven.

Main turbines are 50,000 hp. (about) quadruple-expansion Parsons reaction units with reversing wheels in the second IP and LP stages. The four stages are grouped around a central gear which through a single reduction leads to the propeller shaft. As is customary on 4-screw ships, the forward turbine room accommodates outboard turbines, the after turbine room the inboard ones. There are a little over a quarter million turbine blades, all hand-fitted!

Four 1,300-kw., 5,000-r.p.m., quadruple-expansion turbines, one a spare, in a turbine station between two after boiler rooms provide power for pumps and boiler auxiliaries, using steam from the main boilers. They are geared down in one reduction to drive 600-r.p.m., 220-volt, d.c. generators, and each has its own auxiliaries, thus can be operated independently. This turbine station is independent of any other, but is interconnected to some extent for emergencies with the forward turbine station which supplies power for services and deck machinery. In the forward station are three 1,300-kw. 5,000-r.p.m. turbines, one a spare, provided with steam from the Scotch boilers. All deck machinery and services are electric driven, kitchens are all-electric, and electric heaters supplement the heated-air outlets in cabins. These turbines thus supply energy for a variety of services, including 520 electric motors totaling 13,500 hp., 30,000 lamps in 10,000 fixtures, special lighting, and even preheating jacket water in the dieselized lifeboats! This ship has the first installation of all-motored steel lifeboats, her 24 boats each having its own diesel set, and two being equipped with 18-hp. auxiliary diesels for radio sets. Diesels are in water-tight insulated compartments, so can be readily warmed up electrically and can be run when the boat is flooded. Emergency power requirements are provided for by two gasoline-driven 75-kw. emergency sets up forward on C deck.

Queen Mary coming down the Clyde. To get an idea of comparative size, the letters on her bow are 2½ ft. high and 55 ft. long. Schrage photo



STEAM-JET COOLING
Lengthens Distilleries' Season

During the summer months, many distilleries are forced to decrease production because of insufficient cooling water. Two plants will keep right on going. Here's how they do it

By J. W. McNulty
Condenser Engineering Dept.,
Westinghouse Electric & Mfg. Co.

EARLY in 1935, the Schenley Management, realizing the advantages that could be obtained from operating their properties throughout the year at full capacity, authorized Carl J. Kiefer, consulting engineer, Cincinnati, Ohio, to purchase and install water-cooling apparatus for two of their largest distilleries, James E. Pepper & Co., at Lexington, Ky., and Geo. T. Stagg Co., at Frankfort, Ky. Steam-jet vacuum cooling was selected as most suitable for this application.

For the Pepper distillery, a capacity of 200 tons per 24 hr. was required, and for the Stagg distillery, a capacity of 400 tons. Both plants required cooling water at 55 deg. F.

The Pepper plant, within the Lexington city limits, is not convenient to a reliable source of condensing water. Consequently it was necessary to use a cooling tower. This tower is built on the roof of the machinery room of the distillery building and supplies water for other requirements as well as for the steam-jet unit.

The steam-jet unit is on a concrete foundation in the distillery yard, and a concrete floor has been provided for convenience. It consists of an evaporator, three steam-jet compressors, a low-level jet condenser, and a 2-stage air ejector on a jet-type inter-condenser to evact the jet condenser.

The evaporator is designed to circulate 375 g.p.m. of chilled water. Water enters the evaporator at 67.8 deg. and leaves at 55 deg., being returned to the distillery by a 2-stage centrifugal pump operating at 1,160 r.p.m. and driven by a 40-hp. weatherproof motor. Make-up water enters the evaporator from the city mains through a float-controlled valve.

The condenser requires 800 g.p.m. from the cooling tower, and this water, together with the condensed steam, is returned to the tower by a single-stage pump, driven at 1,750 r.p.m. by a 50-hp. weather-proof motor.

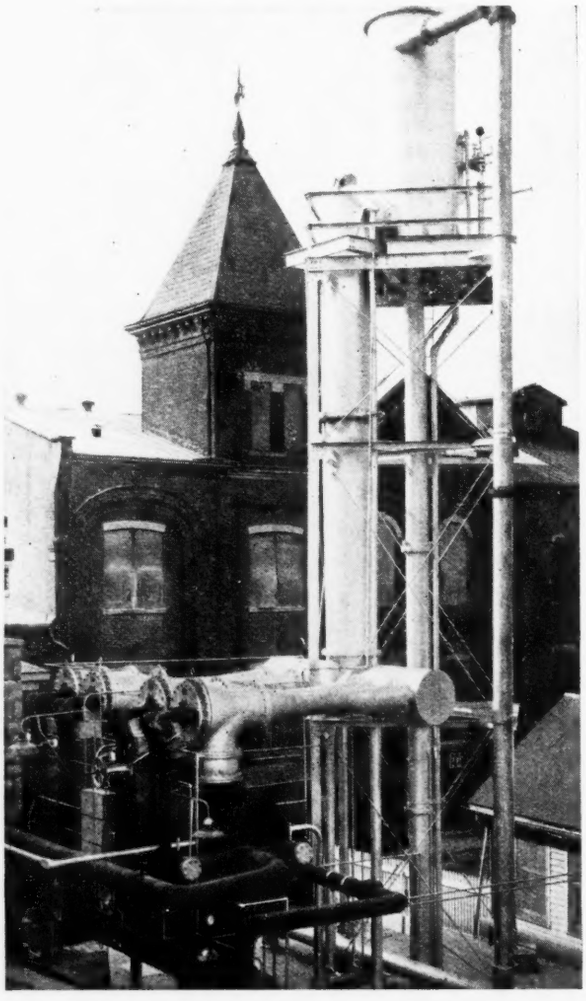
Steam is supplied to the steam-jet compressors at 115 lb. pressure and 96% quality. Two compressors are controlled automatically, to cut in and out in response to temperature changes of the chilled water leaving the evaporator. The third compressor is hand controlled. Chilled-water temperature is thus maintained automatically within 1 deg. plus or minus of the required temperature over the entire operating range of the unit, and steam consumption is kept to a minimum.

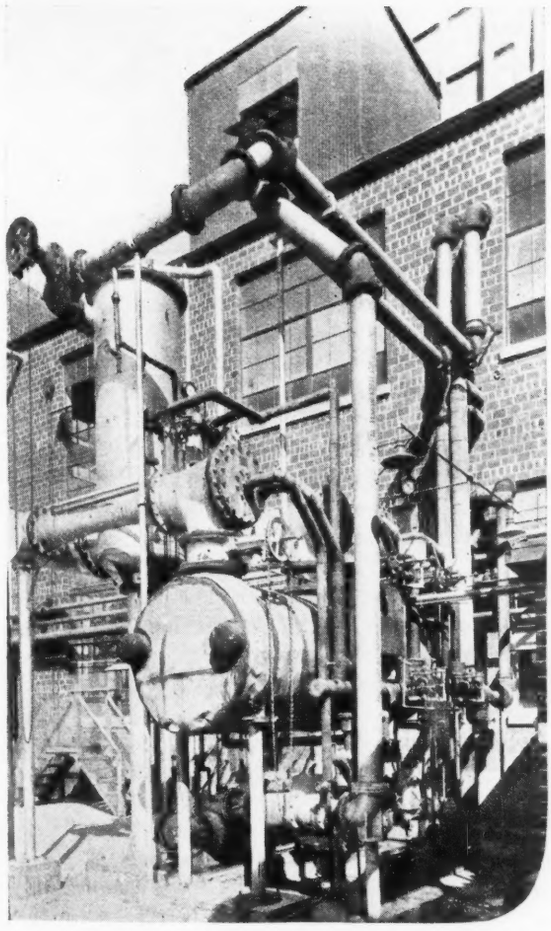
Steam is supplied by the existing boilers, and this additional load smoothes out normal steam load fluctuations and increases boiler-plant efficiency. Thus, the only steam cost chargeable against the steam-jet unit is the additional fuel cost.

Stagg plant obtains its condensing water from the Kentucky River by means of motor-driven vertical submerged pumps. These pumps also supply all other condensing water required by the distillery. Water for mashing is supplied from springs. A large storage reservoir on an adjacent hill is used as a surge bank, for the condensing-water supply system.

The steam-jet unit is in the open across a road and railroad track from the distillery building. It likewise is on a concrete foundation and has a concrete floor underneath to form a pit for the chilled water pump.

The barometric condenser, four steam-jet compressors and evaporator which provide chilled water for Geo. T. Stagg Co., Frankfort, Ky.





Steam-jet cooling unit of James E. Pepper & Co., Lexington, Ky. The cooling tower is barely visible on the roof

This unit consists of an evaporator, four steam-jet compressors, a barometer condenser and a 2-stage air ejector with barometric intercondenser.

The evaporator is designed to circulate 750 g.p.m. of chilled water at the same temperatures as the Pepper unit. Chilled water is handled from the evaporator by a 2-stage centrifugal pump operating at 1,160 r.p.m. and driven by a 60-hp. weather-proof motor. Make-up for the evaporator is obtained from the city mains through a float-controlled valve.

On a steel frame tower above the other apparatus is the barometric condenser, at such a height that it can lift its water from the supply reservoir. The condenser tail pipe terminates in a concrete hotwell beneath the condenser, and water overflows from this well through a terra cotta pipe line back to the river. Air ejector and inter-condenser are mounted with the condenser atop the tower. The tail pipe from the intercondenser also terminates in the condenser hotwell. Maximum condenser water requirements are 1,825 g.p.m.

The steam-jet compressors are supplied with motive steam at 115 lb. pressure and 96% quality. Three compressors are controlled automatically, to cut in and out in response to temperature changes of the chilled water leaving the evaporator. The fourth is hand controlled.

Both units were placed in service at the beginning of the 1935 cooling season and have operated successfully throughout. Due to automatic control of the compressors, very little attention is required, so both units are attended by the regular distillery crews.

At both plants, chilled water circulates in a closed system through the mash-, and slop- and yeast-cooling coils and still condensers and back to the evaporator, so that the water is uncontaminated. This prevents fouling of the heat-transfer surface in the coils, thus refrigerating output is always a maximum. Furthermore, the absence of chemicals throughout the system avoids any possibility of contaminating and spoiling the product. All chemicals are objectionable, and particularly ammonia, which has a decided inhibiting action on yeast growth, with consequent injurious effect on the formative process.

EXHAUST LINES

By E. J. Tangerman

One reader wrote in just after Christmas from one of the South European countries. After wishing us a "Marry Chrismus" and Happy New Year, he asked for the names of American companies manufacturing guns, pistols, armored cars, tanks, planes ("both persecution and bombing"), machine guns, etc. It may be a Merry Christmas, but there's no good will towards men.

Which reminds me of another letter about two years ago. A lady wrote in, explaining that her husband, long a subscriber to *Power*, had been dead for two years, so she didn't think she needed to renew his subscription. "But," she wrote, "Whenever Tom was in trouble, he wrote you, and you told him what to do. Well, my sewing machine squeaks, so I wish you'd tell me what to do about it." We wrote back, tactfully suggesting a little oil. Back came her reply: "Thank you very much. That was what was the matter with it!"

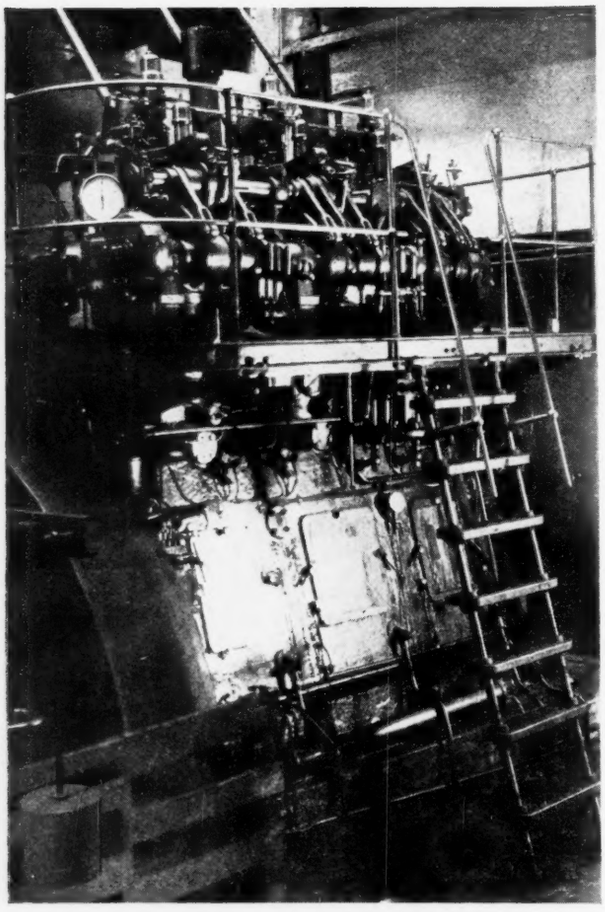
Out on Midway Island, 1,000 miles Northwest of Hawaii, and at Wake Island, another 1,000 miles west, Pan-American Airways has put in landing fields for its transpacific "Clippers." Diesel tractors and power units do the heavy work and lighting. Of course all their fuel has to be carried to them, so it costs money. One way to cut the bill a little is already in use—lubricating oil drained from the planes is burned in the diesels, thus serves two purposes.

When heavy snows prevented line inspections by Interstate Power Company crews, the manager of Dubuque's municipal airport equipped a plane with skis, obtained a license to fly low and took over the inspection work. It was the first time the company ever has checked the system by air.

It costs real money to get fuel to out-of-the-way places. We mentioned a mine diesel plant down in New Caledonia that gets fuel by way of Australia in tankers, then in small tank tramps to the island port, then barrel by barrel aboard a coastwise vessel to a cableway and ashore. Donkeys and cable railway carry it from there up the mountain to the mine. It takes nine months for a repair part to get there.

Probably the world's oldest existing water pipes were dug up in Egypt recently. They were hammered copper, made about 2750 B.C., and were used in the temple of King Sa-Hu Re at Absuir. The project required 1,300 ft. of 1.8-in. pipe, says the N. J. Public Utility Information Committee, and sections were each about 3 ft. long. Seams were unsoldered, being formed by overlaps closed by hammering. This pipe was laid in stone conduits and covered over with a cement made of gypsum, thus giving a line that was practically water-tight.

This Engine Runs



This 3-cyl., 150-hp. Rupamotor runs on coal dust for Kosmos G.M.B.H.

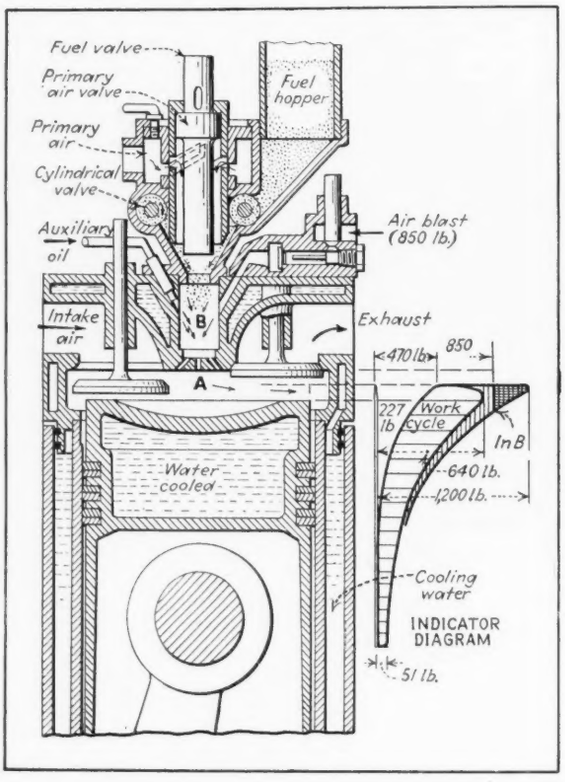
RUDOLF PAWLIKOWSKI began, twenty or more years ago, to develop the diesel engine along the lines envisaged initially by Dr. Diesel—burning coal dust or pulverized coal fed through a rotary valve from a hopper. Mr. Pawlikowski has now added a "supplementary chamber," at *B* in the diagram, in which the fuel is retained practically throughout the compression stroke. It is thus heated about ten times as long and intensively as in a diesel, reaching about 860 deg. F. at maximum compression pressure of about 470 lb. gage, meanwhile mixing thoroughly with primary air. Therefore, the engine is able not only to operate, but to start, on any pulverized solid or liquid fuel that contains heat. Transition can be made from one fuel to another while the engine is running.

The diagram shows the "Rupamotor" principle of operation. Fuel from the hopper is apparently metered through the cylindrical valves, which also serve to break up any cakes or lumps. The lower end of the fuel valve seals the opening into supplementary chamber *B*, and its upper end is enlarged in cross-section to control the primary air supply. Fuel is dropped through the fuel valve shortly after the beginning of the intake. The desired amount of primary air passes between the fuel and cylinder valves through two sets of spiral slots on the fuel-valve plunger, which itself may be rotated by hand or regulator to advance or retard cutoff of auxiliary air. This permits control of the charge in the chamber and elimination of residue from the chamber. Primary air whirls the charge and also cleans the seat of the fuel valve as it closes. This air is drawn in by the engine itself, just as is the fuel, making it possible to operate the engine without pressure on either air or fuel. There is, however, a controllable compressed-air injection valve that admits auxiliary air as desired. This intermediate valve is kept closed until the charge is blown from the chamber into the cylinder, and the pressure drops to the 650 lb. cylinder pressure. Then pressure air is injected to scavenge the chamber. Thus slow-distilling fuel particles are blown into the cylinder somewhat sooner. The chamber itself, however, can normally be kept clean and free of ash without this air.

The diagram also shows a fuel-oil nozzle terminating in the chamber. This permits the engine to be started or run on oil, or a fine spray of oil to be admitted as supplementary fuel if the primary fuel is hard to ignite. This may happen if it is too damp, too coarse, or contains too much ash.

Mr. Pawlikowski compares operation of his engine with that of a Bunsen burner, in that successful combustion requires addition of some air before the fuel is ignited. Such a theory has been borne out by the spectrum analyses of Prof. Neumann of Hannover. Primary air mixing in the Rupamotor is like the air addition at the base of the burner. Hydrocarbon molecules in the fuel undergo early splitting up and preoxidation, because they are heated while they are still enveloped in primary air. The more volatile parts evaporate first, the heavier particles crack and their hydrogen goes into the formation of benzines, perhaps accompanied by dissociation

Supplementary chamber B has higher combustion pressures



On Anything That Will Burn

Including:

Hard Coal, Soft Coal, Lignite, Peat, Cokes, Potato Peelings, Sawdust, Leaves, Wood Residues, Pine Needles, Hay, Cotton Hulls, Corn and Cereal Stalks, Soy Beans, Fruit Peelings, Cotton Hulls, Palm Seeds, Residues of Peanuts, Olives, Palm, Cocoanuts (after oil extraction)

of any moisture present. Then burning takes place in the secondary air. Just as in a Bunsen burner, adjustment of the primary air affects the intensity and duration of the partial preignition in the chamber, therefore also in the main cylinder *A*.

Maximum ignition pressure can be varied from 468 to 682 lb. gage, a range of 20%. While pressure in the cylinder is at 640 lb., the explosive pressure in the chamber will reach 1,200 lb. This overpressure forces the charge into the hot compressed air of the cylinder. The narrower the vents between chamber and cylinder, the higher the chamber pressure. Vents are arranged so that they distribute the charge properly over the cylinder space.

Apparently no difficulty is encountered from the ash, for one engine converted from a diesel has shown only 7 mm. of cast-iron cylinder liner wear (420 to 427.5 mm. max., about $\frac{1}{4}$ in.) in 20 years of testing under various fuels while supplying power for the company's machine shop. With present piston-rings, good compression can be obtained even with wear of as much as 2.5% of cylinder diameter. Liners and pistons are now being made of the new, hard, automotive alloys, tests indicating that they should be good for at least 4,000 to 6,000 hr. Replacement is quick and easy.

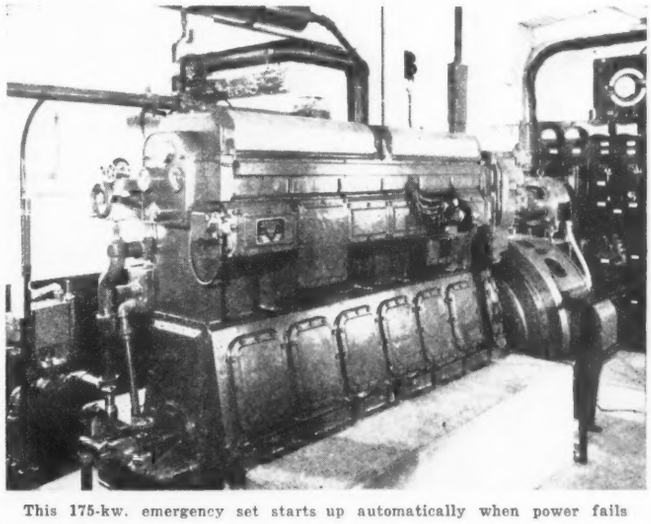
Thermal efficiencies given for the stationary Rupamotor are 32% with anthracite, 30% with lignite. For the automotive Rupa, efficiencies given are 22.5% with lignite having 4-6% ash, 23.5% with anthracite having 2-5% ash, 24.5% for high-grade pulverized coal with 0.1% ash, 22% with sawdust "flour," and 21% with forest and field residues that are finely ground. Mr. Pawlikowski does not give comparative fixed or operating costs on his engine, although he claims it to be cheaper to operate than a "20,000-kw. steam turbine."

Gas Standby Set Takes Load in 15 Sec.

GLASS processing goes along smoothly as long as power supply is constant. But stop the blowers for as little as 10 min., and the glass will burn through its tanks, or vary the voltage or current a little, and the rolled glass will be imperfect.

Pittsburgh Plate Glass Co. buys its power for the Mt. Vernon, Ohio, plant, but to avoid any chance of power failure, the company has just installed a 275-hp., 4-cycle Cooper-Bessemer gas engine driving a 240-volt, 175-kw. generator and a V-belted exciter. A relay operated by a 32-volt battery turns on the ignition, opens the gas and water valves and cranks the engine as soon as power supply fails. The engine fires within 2 or 3 sec., comes up to speed in 5 sec., its voltage is regulated, and it takes over the load through the action of a second relay. A 230-volt, 20-kw., d.c. storage battery, good for an hour's operation under essential load, carries over between.

Standard equipment was used for almost all the installation, including a standard gearmotor and three conventional relays, the other three relays being built up of standard parts. Safety devices installed include automatic throttle control, thermostatic water temperature control, switchboard indicating lights to show that automatic gas and water valves are open, and automatic over-speed switch. An alarm bell begins to ring as soon as power-supply fails, and keeps on ringing until the operator has checked up the engine to see that it has taken load.



This 175-kw. emergency set starts up automatically when power fails

The unit is tested weekly through the full series of operations. During the one power failure since installation, the unit took load within 15 sec. H. F. Hitner and H. W. Gardner, company electrical engineers, are responsible for the installation. Charles C. Dice is assistant master mechanic and chief electrician, A. C. Oakes master mechanic and John Thompson construction electrician.

WHY BOILER PRESSURES ARE CUT

II.

Section I of this article appeared in March POWER, pages 148-149. Publication of this second section was held over to make room for last-minute flood reports.—Ed.

By Harry M. Spring

New York, N. Y.

WEAKENING of a boiler shell by reduction in thickness may be caused by mechanical injury to the boiler plate. While this is most often caused by defective plate rolling or by damage during transportation, there are several operating conditions which may cause such an injury.

Deep gouges have been found on internal surfaces of water-tube boilers where the deflecting baffle plate or some similar object becomes loose, then chafes back and forth against the boiler surfaces, causing abrasion. Where this reduction in thickness affects a small area, say 2 in. longitudinally or 4 in. circumferentially, and not over 50% of the thickness is damaged, the depression is usually built up by arc welding. Longer, deeper gouges require a reduction in operating pressure, or repair by cutting out the defective shell plate and riveting on a patch.

Serious mechanical damage to a boiler sometimes results from furnace explosions or violent flarebacks. These most often occur with fuels burned in suspension, such as pulverized coal, oil and gas. They may also be caused by gas accumulations in stoker-fired installations, usually resulting from a tightly closed damper with banked fires. Care in providing the proper ignition and draft will prevent most flarebacks with fuels burned in suspension.

Damage from furnace-gas explosions is usually most pronounced on the boiler setting. In more serious cases, riveted seams may be sprung, cracks started or extended, or the entire setting blown out, followed by collapse of the boiler. Easy-opening explosion doors are important preventatives in minimizing the violence of these explosions.

Sudden opening of a stop valve when cutting in a boiler may not only invite rupture of steam lines and headers by drawing out a slug of water, but the accompanying shock to the piping is transmitted back to the boiler. Leakage may be started at riveted seams, especially around the steam nozzle. Rivet-hole fractures at the nozzle are frequently caused by such a shock, and there are possibilities of even more serious results.

Care in equalizing pressures slowly between the header and on-coming boilers, and in prevention of priming from high water levels, are most important in preventing such damage.

Bulging sidewalls or defective foundations may throw a considerable stress onto the steam nozzle and other parts. Pulsations in steam flow, caused by a reciprocating engine drawing steam through too small a steam line, are often the cause of rivet-hole fractures in a steam nozzle. Such fractures are known as "fatigue cracks." Proper anchorage of the steam piping and use of sufficiently large pipe avoid this difficulty.

Laminations

Laminations, a cause of weakness, are beyond control of the operating personnel. They are caused by slag or other foreign matter rolled into the plate. While external surfaces appear sound, there is a void or break in the plate structure, which is a comparatively great heat insulator. The result is that instead of a solid, more or less homogenous material throughout the plate thickness, the plate is rolled in layers. If this section of the plate is exposed to high temperatures, as the shell of a fire-tube boiler over the fire, the outside layer of plate so exposed will blister, and be of no value for strength.

These blisters are chipped off in each direction to the end of the lamination. The maximum allowable pressure is then recalculated, basing it on the remaining thickness of the shell. Or if a higher pressure is desired and the affected area is not too large, it is cut out and patched.

Cracks in boiler plate are often the result of design of the boiler or the installation. They are also caused by stresses set up during construction. Several causes are under the control of plant personnel.

Cracking of Plate

Intercrystalline cracking of boiler plate has been caused in high-temperature service by hydrogen penetration and hydroxide action between grains of the metal. While a slightly alkaline condition of the boiler water is necessary to inhibit corrosive action, too high an alkalinity may cause embrittlement and cracking of the plate. An abnormal sodium carbonate or sodium hydroxide concentration of a boiler water lacking in sulphates greatly favors such a condition. Calking of inside seams is generally recommended in boilers where feedwater is known to be of this nature.

Fatigue cracks are not uncommon in boiler plate under a frequent high and low, cyclic stress. Normal and properly controlled plant operation should not cause them. Oil- and gas-burning installations do, however, operate under automatic pressure control of the type

which extinguishes the fire at a certain predetermined pressure, and lights the fire after a definite pressure drop. Such control systems should be adjusted to operate with as small a pressure differential as is possible and practical. While induced stress reversals caused by by pressure and temperature changes will be more frequent, the fatigue endurance of the metal will be greater than if the cyclic stresses vary over a greater range.

Corrosion of the metal causes a great reduction in fatigue endurance. Repeated stressing of a metal in presence of a corrosive element allows both the rate of intercrystalline corrosion penetration and the fatigue breakdown to be much accelerated.

Firecracking of plate at riveted seams exposed to radiant heat of the fire is neither uncommon nor serious. This usually occurs where lapped plates cause a double thickness of metal between the fire and the water sides of the plate; as in vertical and furnace seams of firebox boilers, girth seams of horizontal tubular boilers, etc. High temperature and expansion of the exposed surfaces cause the cracking. This condition is more frequent where thick boiler plate is used, or where the internal surfaces are in such condition that overheating of the plate results. Firecracks are found, however, in clean boilers.

A few slight, hair cracks, extending from the rivet hole to the caulking edge of the plate do not require repairing. If the crack opens up enough to cause leakage, the adjacent rivet should be removed and the crack veed out. This vee may then be electric welded, the rivet hole reamed, and a new rivet driven. Where high furnace temperatures prevail in types of boilers susceptible to firecracking, it is often advisable to build up the caulking edge with a bead of electric welding. The stiffening effect and heat conductivity of this bead usually prevent further trouble.

In cases where the crack extends past the rivet hole into the solid plate, a more serious condition exists. If the crack has not extended more than 1 in. past the rivet hole, a $\frac{1}{4}$-in. hole may be drilled at its extremity. A tapered soft-steel plug is then driven in. This usually "pins" the crack so that it will not extend farther. If the crack continues to extend, it will be necessary to cut out this section of plate and rivet on a patch. Welding should not be attempted in these cases.

Bulging of Plate

Bulging of a boiler is clearly a result of careless or neglectful plant operation. While a slightly bulged plate will not necessarily result in a cut in pressure, it is a condition which shows poor management and it should be avoided. A sharp bulge in the plate will cause a corresponding reduction in thickness due to the "stretch" of metal at the elongated sections. Permanent damage to the metal from overheating and burning may also result. More severe cases require heating and driving back the bulged plate, or cutting out the defective section and applying a riveted patch.

Bulging of the lower parts of a boiler operating under normal pressure is caused by accumulations of scale, sludge oil, or grease in the boiler or by dangerously low water levels with the boiler in operation. Bulging of the upper surfaces of the shell plate is caused by poor masonry conditions which allow high-temperature gases to contact the shell plates above the waterline.

Proper feedwater treatment for scale prevention does not permit use of boiler compounds that are said to be a "cure" for all waters under all conditions. Careful and periodic analysis of the water is necessary, and from the results of this, the type and extent of treatment should be determined. Conditioning of water for scale prevention closely parallels treatment for corrosion control. If possible and practicable, the water should be treated outside of the boiler, by filtering, evaporating, softening—whichever the analysis shows necessary. Internal treatment is usually most practicable in small plants and is sometimes a necessary supplementary treatment in larger plants.

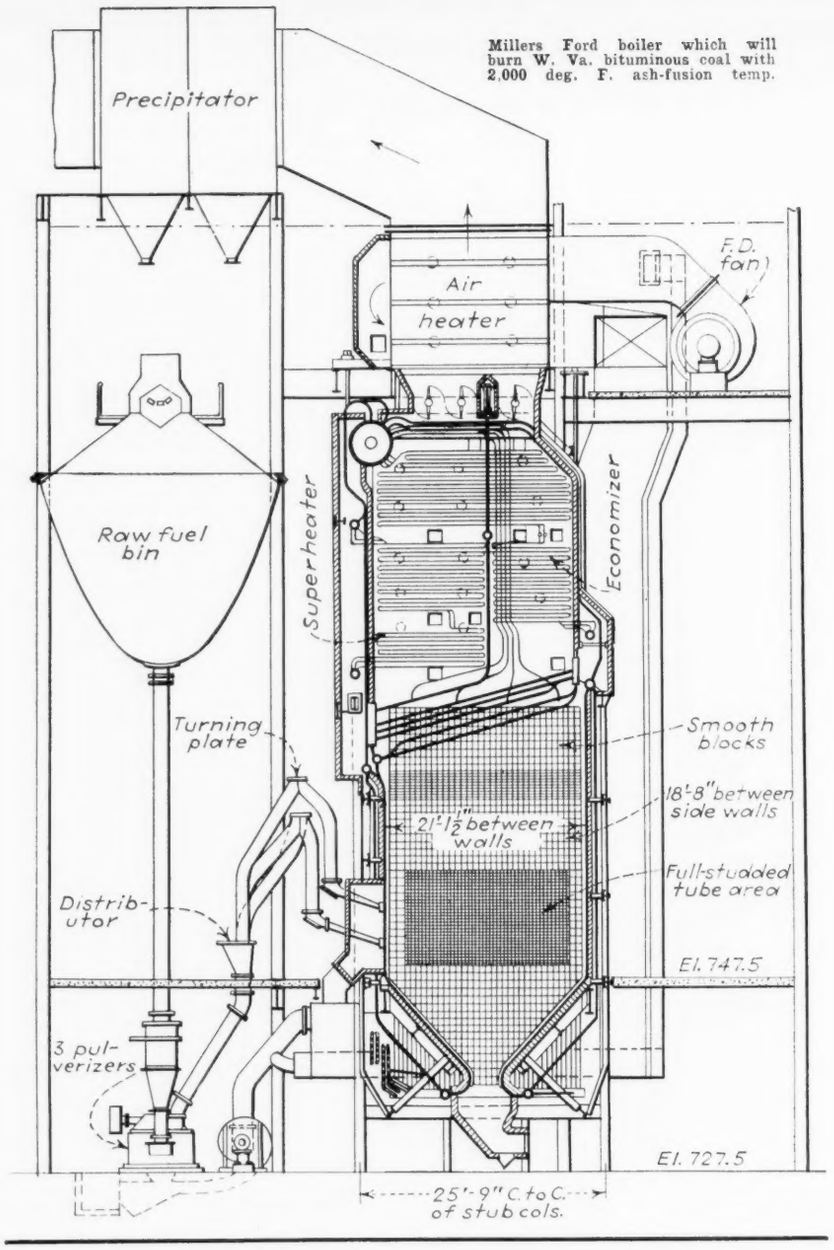
A heavy scale not only causes loss in efficiency by poor heat transfer, but may also cause serious overheating of areas exposed to high temperature. A similar condition is caused by oil or grease which enters the boiler with the feedwater. Use of efficient, exhaust steam purifiers and a minimum quantity of high-grade lubricant for reciprocating engines are preventatives where such condensate is returned to the boiler.

A defect in a section of boiler plate, which requires cutting out and applying a riveted patch, requires recalculation of the strength of the boiler, based on the riveted seams of the patch. This may result in a necessary reduction in boiler pressure, depending upon the area affected, the angle of the patch seams and their constructional details. Needless to say, the only preventative against these conditions is to eliminate any of the previously mentioned conditions controllable by the plant personnel, which might cause such defects to develop. Care in laying out a riveted patch to have it of such shape that all the seams will approach the same angle of the girth seams will also aid in maintaining boiler strength.

Wet-Place Conductors—In addition to moisture in certain power circuits we had temperatures of around 200 deg. F. During certain periods condensation completely submerged the cables. Fortunately this cable had reinforced-rubber and varnish-cambric insulation which offered a measure of protection against moisture. There were only two ways of permanently curing our trouble, reroute the conduits, or use cable designed for such conditions. A study of cost to reroute the conduits showed it to be too expensive and it was decided to use a cable that would operate successfully in the conduits. Lead sheathed, asbestos, varnish-cambric insulated cable indicated it had the ideal charactertistics, giving uninterrupted service under conduit conditions of 250 deg. F. and complete submersion. No trouble has been experienced since. —K. B. HOFFMAN.

Woodcliff, N. J.

"TOPPING" MILLERS FORD



Millers Ford boiler which will burn W. Va. bituminous coal with 2,000 deg. F. ash-fusion temp.

FOR the 1,200-lb. pressure extension to existing low-pressure system at Millers Ford Station (POWER, *April, page* 231), Dayton Power & Light Co. will install two pulverized-coal fired B&W boilers of the high-head single-pass type complete with Bailey water-cooler furnaces, B&W superheaters, economizers, and air heaters.

The boilers are designed for 1,350 lb. pressure, will operate at 1,250 lb. and have a maximum capacity of 375,000 lb. of steam per hr. The superheaters will be capable of producing 900 deg. F. total steam temperature at maximum capacity. The tubular-type air heaters have a heating surface of 24,000 sq.ft. each, and the economizers 20,650 sq.ft. each. Each boiler is of cross-drum type with a low bank of tubes between the furnace and an upper section containing superheating and economizing surface. A vertical water-cooled baffle divides this space in such manner that the superheater is contained in the front section, part of the economizer surface in the rear section, and, over these, economizer surface extending the full length of the unit. The boiler tubes interposed between the furnace and the superheater and economizer sections are arranged to provide an effective slag screen and maintain the gas at a temperature suited to the design temperature of the superheater tubes.

Constant superheat temperature will be maintained over a wide range of capacities by means of the dampers, located at the boiler outlet, which control the gas flow through the unit. The superheater is designed to furnish the desired steam temperatures at approximately half load, with all the gas passing over the superheater surface By manipulation of the dampers, none of the gas comes in contact with the superheater surface when bringing the boiler up to steaming condition; adjustment of the dampers when the unit is placed on the line insures that all gas passes over the superheater until the unit is operating at the desired temperature, at about half its maximum capacity. At all higher capacities, the rear damper is so adjusted that sufficient gas is bypassed around the superheater to maintain the desired constant steam temperature.

The hopper-bottom furnaces are completely watercooled and are designed for a heat liberation of 39,500 B.t.u. per cu.ft. per hr. at maximum rating. Smooth-block construction is used throughout, except for a 10-ft.-wide band of refractory-covered stud-tube construction extending around the furnace at the burner elevation to aid ignition and minimize carbon loss at the lower ratings.

Each unit will be direct fired with the B&W direct-firing system, with features for relibality, ease of control, responsiveness to load changes, and sustained high efficiency. The Type B pulverizers, three per boiler, will have single rows of grinding balls.

These boilers will deliver steam to a 25,000-kw. GE turbine driving a 3-phase, 60-cycle, 12,000-volt, hydrogen-cooled generator. The turbine will exhaust into the present station header at 235 lb. and 575 deg. F.

Boiler feed pumps include two high-pressure and one low-pressure turbine-driven pumps, each capable of delivering feedwater against 1,500 lb. pressure. Forced and induced-draft fans are both designed for 12-in. static pressure, the F.D. fans being 113,000 c.f.m. units, the I.D. 200,000 c.f.m. The station will also include Cottrell precipitators.

Union G.&E. Co. Tops West End Station

UNION Gas & Electric Co., Cincinnati, Ohio, has purchased a 35,000-kw., 3,600-r.p.m. turbo-generator unit from Westinghouse Electric & Mfg. Co. to be superimposed on the present equipment at West End Power Station. The generator is a 13,200-volt, 80%-power factor unit, hydrogen-cooled.

The turbine will operate at 1,200 lb. and 900 deg. at the throttle and will exhaust at 260 lb. Steam for this unit will be supplied by three Babcock & Wilcox boilers of special design having some of the features of the integral-type boiler. They are being built for 1,450-lb. pressure and 925 deg. when delivering 350,000 lb. of steam per hr., and will be fired with pulverized coal using a slag-tap furnace. This installation is scheduled for operation in 1937.

THE LOWDOWN ON BUILDING UP

RECENT developments in metal spraying brought out by R. A. Axline, president, Metallizing Engrg. Co., Inc., at an A.S.M.E. meeting in New York, April 7. Among new applications of most interest to power engineers is that of spraying aluminum on refractory walls of a boiler furnace. Fisher Body Co. finds that the heat of the furnace causes the aluminum to combine with the refractory surface and form aluminum silicate. This increases the life of the wall, makes the bond stand up better, and reduces slag adherence.

Other satisfactory new applications include spraying lead on power-plant breechings, zinc over welded seams in galvanized refrigerating coils and at the water line on ice cans, and stainless steel to fill cavitation pits on waterwheels. The Navy is spraying air-cooled cylinders and airplane cowlings with aluminum to resist corrosion from salt-water spray. In the newer process of babbit-spraying bearings, one essential was redesign of the bearing shells. Shells have always been designed for a half inch or so of babbit because it had to be cast in place, but the spray gun will put in $\frac{3}{32}$ or $\frac{1}{16}$ in., enough for wear, yet giving higher rates of heat transmission.

Procedure in babbit spraying involves the usual fluxing and tinning, just as in casting a bearing. This tinning is then heated with a blowtorch just to the point at which it is molten, and spraying started while the blowtorch is still playing on the tinned surface.

Applications

Spraying for overcoming corrosion is being used successfully where the operator understands the essential leafy or scaly structure of the sprayed coating, thus finishes the surface properly afterwards. Some materials, for example, will seal themselves through chemical action which creates an oxide that fills the crevices, but in many cases this chemical action does not occur. Common practice now is to finish tin and lead coats by wirebrushing afterwards, and harder metals by grinding.

Great present use for spraying is in building up a surface subject to or worn down by abrasion, common materials being steels, stainless and Monel. Steels are ordinarily considered in four groups, 0.1, 0.4, 0.8 and 1.2 carbon, the latter two being used principally for journal surfaces and requiring grinding to finish. The two lower groups can be finished by machining. Only two groups of stainless are sprayed, either a low-carbon, 18-8 steel or a high-carbon, high-chrome steel. The latter must be finished by grinding. Monel and nickel are being used in the chemical industries particularly, building up pump shafts, etc. Zinc is sprayed for corrosion resistance against common materials, particularly salt water, aluminum against hydrogen sulphide and alkalies, tin in milk coolers, to repair pits in glass-lined tanks, etc., and lead on exhaust-fan blades subject to acid fumes and for similar use. Some bronze, is being sprayed, particularly Tobin bronze, because of the ease with which it can be machined. Brasses and coppers find very limited application.

Research has indicated that the proportion of metal deposited to that sprayed varies from 60% with lead through 78% for zinc, 88% for copper, to as high as 92% for steel.

It is now possible to predict the composition of a coating, as long as the operator makes certain he maintains a neutral flame. Normally, variations come from temporary shifts in the regulator itself, so can be taken care of by using two regulators in tandem on each line. Thus one compensates for the other's irregularities. Efforts to heat-treat sprayed steels have not been particularly satisfactory, although there is no reason why it cannot be done. The principal reason why no extensive effort has been made to develop this phase is because it is usually easier to spray an alloy which will give the required hardness without heat-treating.

One of the New York subway systems has done some successful work on spraying the low-pressure stationary blading of a turbine. Lock gates in Belgium and France sprayed with zinc 14 years ago are still in good condition, but no American spraying thus far is old enough to make any proper comparisons. Usual jobs are only three or four years old. Present indications are, however, that metal spraying and paint cost about the same on a 10-year life; for periods less than that painting is cheaper. Plating, where it can be done, is much cheaper than spraying.

Usual procedure now, to insure proper thickness of coating, is to measure out a weight of wire equal to the amount to be deposited on a given area plus the amount which will be lost in spraying, and then have the operator apply all that material to the given area. New fan-type nozzles too are giving a more uniform thickness. Coatings can be put on over a surface with extra thickness to fill pits, etc., but a very thick coating on a flat surface shrinks in cooling, thus lifts at the edges.

Almost all shafts are now prepared for spraying by rough V-threading, using a tool set below center on the lathe so that it produces a tearing, chattering action. Many operators tend to forget the three great fundamentals of successful coating—absolute cleanliness (no oil on or near the surface), appreciable roughness (too small a grit or sand in the blast produces pits too small for anchoring), and sufficiently fine atomization, particularly in first coats (too fast a feed makes for coarseness and trouble).

The higher-carbon steels cannot be sprayed on shafts at a very high rate because longitudinal cracks appear when the coating cools. This can be overcome by directing an air blast at the back of the section being sprayed so that it is cooled just as fast as the spray heats it. In this way the advantages of better homogeneity and less oxide with faster coating can be obtained.

Some time ago, A. W. Gruber of Condenser Service & Engrg. Co. delivered a talk before the Florida Engrg. Society which included a number of points of interest on new spray applications. Abstracts of his remarks follow.

A hydraulic ram was scored by a tool left in the packing. A new ram would have cost $5,000, plus the cost of tearing out a wall to permit removal of the old ram, plus installation costs. Instead, the scores were sprayed with low-carbon steel and finished in place, at a saving of 90%. The same company had a 42x60-in. intermediate cylinder on a ship engine with scores $\frac{3}{16}$ to $\frac{5}{16}$ in. deep all along its length. These were chipped, prepared, grit-blasted and filled with low-carbon steel. After a 9,000-mile voyage, the repair was inspected and found all right.

Mr. Gruber's company is also filling in cracks in gasoline and diesel engine cylinder blocks, and ice machine and air compressor cylinders. This works out all right too, realizing of course that the filling job is just a patch, not a part of the block. A number of diesel cylinder liners have been built up successfully, as well as aluminum cast-iron piston skirts. Valve and piston rods have been built up and in service for from three to five years without trouble. In each case the scored area is undercut, grit-blasted and sprayed, then ground to required size. Finished surfaces show a Brinell up to 350. Crankshafts, crosshead and wrist pins, and similar parts are likewise built up.

Eroded sections of induced-draft fans and turbine casings between blades have been built up. A sootblower fan, previously rubber-coated, was built up with high-carbon steel topped by a thin coating of lead. Condensate tanks of one power company were under the coal pile, hence were corroded by sulphuric acid formed by water seeping through the coal. Formerly the tanks had to be dug out and welded every few months, but since being sprayed with 0.030 in. of lead and wirebrushed, they have stood up for nine months with no apparent corrosion yet. Stoker tuyeres and grate bars sprayed with aluminum, then heat-treated, have had life increased five to nine times. Feed-pump plungers and turbo-feed-pump casings and impellers have been built up successfully with special alloys. Stacks have been coated with aluminum and zinc to resist heat and dilute acids in the flue gas.

Courtesy Air Reduction Sales Corp.

HOW BIG A PIPE FOR

Pipe-line friction is a prolific source of mistakes in pump applications. The simple method here given avoids these errors by analyzing pipe-line characteristics before installation

WHEN pumps are selected and installed, good engineering dictates a careful study of conditions to insure obtaining efficient equipment and economical size and arrangement of piping. To say that a pump is no better than its piping system is not far from right. If piping head losses are excessive, the pump must operate at reduced capacity, and efficiency and the power consumption will be high. These objectionable and costly conditions can be avoided by simple methods of analysis, which include combining pump and pipe-line friction-head characteristics.

Performance of a centrifugal pump can be readily understood from its characteristic curves, such as Fig. 1, supplied by the manufacturer. These curves are for a 3-in., 1,750-r.p.m. pump. The capacity-head curve shows the relation between gallons pumped per minute and total head in feet against which a given capacity can be discharged. This curve definitely fixes the pump's operating range, and it must operate at some point along the curve.

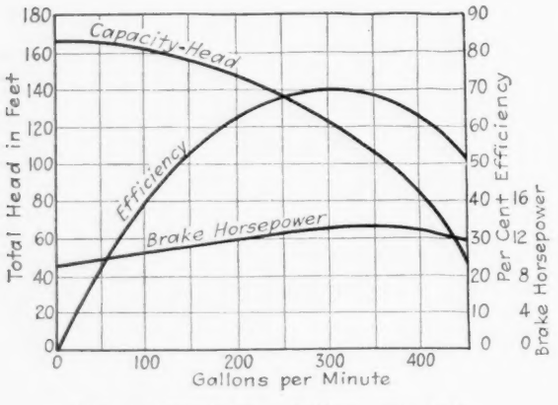


Fig. 1—Capacity-head, efficiency and brake-horsepower curves for a 3-in. centrifugal pump

Table I—Friction-Head Data for 2½-In. Suction and 3-In. Discharge Pipe, Fig. 2

1 Gal. Per Min.	2 Fric. Head Ft. Per 100 Ft. of Pipe 2½-In.	3 Fric. Head Ft. Per 100 Ft. of Pipe 3-In.	4 Suction-Line Friction Head, Ft.	5 Discharge-Line Friction Head, Ft.	6 Total Friction Head, Ft.
25	0.92	0.38	0.3	2.2	2.5
50	3.32	1.38	1.2	7.8	9.0
75	7.0	3.0	2.5	16.5	19.0
100	12.0	4.96	4.1	28.2	32.3
125	18.5	7.9	6.6	43.5	50.1
150	25.8	10.5	8.7	60.6	69.3
175	33.5	14.0	11.4	78.7	90.1
200	43.1	17.8	14.8	101.3	116.1
225	54.3	22.3	18.7	129.3	148.0

For example, at its best efficiency, 70%, this pump will deliver about 325 g.p.m. against 115-ft. total head. As this is the most efficient rating, it is the one for which the pump should be selected. If a mistake is made in estimating the head and it is 140 ft. instead of 115, for example, then the pump will discharge only 230 g.p.m. and the efficiency will drop to 66%—a loss of 95 g.p.m. in capacity and 4% in efficiency. The efficiency curve is obtained by plotting per cent pump efficiency against gallons per minute discharged, covered by the pumping range.

The brake horsepower curve shows power required to drive the pump when delivering the capacities indicated. It will be noted that this curve is fairly flat throughout the pumping range. The three curves, Fig. 1, give a fairly complete picture of the duty that can be expected of the pump.

Pipe-Line Characteristics

Performance of the pipe-line connecting the pump, suction well and discharge reservoir may be analyzed from a curve called the pipe-line characteristic. Since this characteristic is very important in selecting correct size of pipe for a pump system, the method of working it out will be given for the pumping installation of Fig. 2.

To simplify the study in Fig. 2, assume that the suction well and discharge reservoir are of sufficient size so that liquid level remains fairly constant during pumping periods. Thus, static suction lift is 10 ft. and static discharge head 70 ft., making a total static head of 80 ft. This head remains constant regardless of pump discharge or type and size of pipe used. In other words, a curve representing total static head would be a straight horizontal line for the entire pumping range, as indicated in Fig. 5.

In addition to static head we must consider friction-

YOUR PUMP?

By Frank A. Kristal
Mechanical Engineer

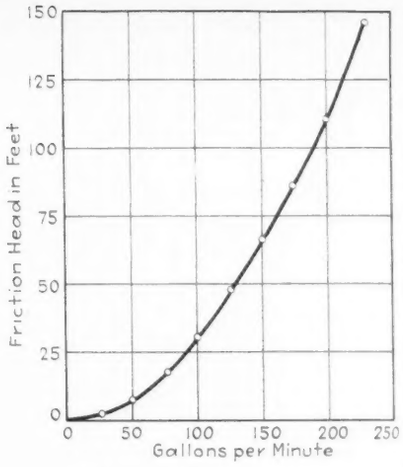


Fig. 3 (left)—Friction-head curve for piping in Fig. 2, using 2½-in. suction and 3-in. discharge

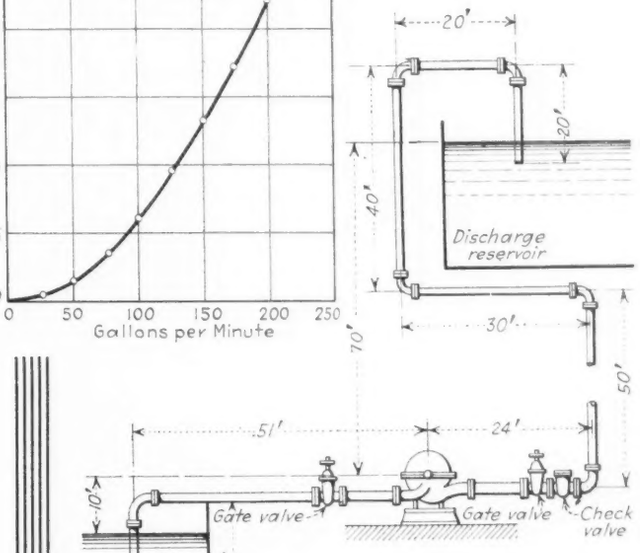


Fig. 2—Centrifugal-pump installation chosen as example

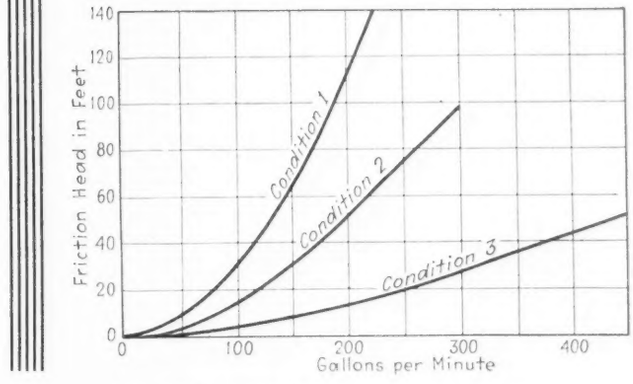


Fig. 4—Pipe friction-head curves, Fig. 2, using 2½-in. suction and 3-in. discharge; 4-in. suction and 3-in. discharge; and 5-in. suction and 4-in. discharge piping

head loss in the suction and discharge piping. This head will vary with the size of pipe used and volume of water pumped. Total static head plus total friction head gives the total dynamic head used when analyzing centrifugal-pump performance.

The Data Sheet, page 272, shows head loss due to friction in pipe of various size at different rates of flow, and provides a means of readily obtaining the friction head. Since pipe fittings, such as elbows and valves may cause considerable friction in the piping system these must also be taken into account. The data sheet also includes a table for doing this.

Assume in Fig. 2 that the suction pipe is 3 in., and the discharge pipe 2.5 in., in diameter. In the suction line there are approximately 76 ft. of straight pipe, one 3 in. long radius elbow, and one 3-in. gate valve. Friction in the foot valve can be disregarded, as a proper-size foot valve is so much larger than the pipe used that its friction is negligible. From the Data Sheet we find that a 3-in. long-radius elbow is equivalent to 4 ft. of straight pipe, and a 3-in. gate valve is equivalent to 3 ft. of straight pipe. Therefore, the suction line has the equivalent of $76 + 4 + 3 = 83$ ft. of straight pipe. The discharge line has 184 ft. of pipe, a 2½-in. gate valve, five 2½-in. standard elbows, and the check valve can be regarded as a 2½-in. globe valve. A 2½-in. standard elbow is equivalent to 6 ft., a gate-valve to 2.8 ft. and a globe valve to 18 ft., of straight pipe. Thus we have for the discharge line, the equivalent of $184 + (5\text{x}6) + 2.8 + 18 = 234.8$, say 235 ft. of straight pipe. Since the friction head in the table is based on friction loss per 100 ft., we may say that the suction line is 0.83 hundred-feet and the discharge line 2.35 hundred-feet in length.

In Table I, the first three columns are taken directly from the Data Sheet. Values in Column 4 are obtained by multiplying the friction factor in Column 3 by 0.83 hundred-feet, therefore represent suction-line friction-head for the various capacities. Multiplying values in Column 2 by 2.35 hundred-feet gives similar data for the discharge line, Column 5. Column 6 values are the sum of those in Columns 4 and 5 and represent total head due to friction at the various water volumes. Using the figures in Column 6 as ordinates and the capacities in Column 1 as abscissae, Fig. 3 can be plotted, which is the pipe-line characteristic for the installation shown in Fig. 2, using a 3-in. suction line and a 2½-in. discharge line.

In a similar way, we can analyze the same installation using other sizes of piping. If we regard the preceding case, Table II, as Condition 1, we can use as Condition 2 an arrangement of 4-in. suction piping with 3-in. discharge piping, and as Condition 3 an arrangement of 5-in. suction piping with 4-in. discharge piping. Table 2 shows a convenient arrangement of the figures and data for the three conditions considered. The last column under each condition gives total friction head which we may use as ordinates, with the capacity in gallons per minute as the abscissae, to plot the pipe-line characteristic for each condition, Fig. 4.

Assume we intend to use the centrifugal pump, charac-

teristic curves of which are shown in Fig. 1. We can get an instructive picture from which to select an efficient and economical installation, by combining pump-characteristic curve, Fig. 1, the horizontal static head line, and the pipe-line characteristics of Fig. 4, as in Fig. 5. It is evident that the most efficient arrangement of piping would be that of Condition 3, with 5-in. suction piping and 4-in. discharge piping. The 5-in. suction pipe would be connected to the 4-in. pump suction opening with a 5- x 4-in. eccentric reducer, and the 3-in. pump discharge outlet would be connected to the 4-in. discharge piping with a 3- x 4-in. increaser. With this arrangement the pump would deliver approximately 330 g.p.m. against a total head of approximately 115 ft. with a maximum efficiency of about 70%. The brake horsepower required for this condition is about 13.5.

Using the piping arrangement for Condition 2, the pump would deliver approximately 220 g.p.m. against 143-ft. total head with an efficiency of 65%, with 12 hp. required. With the piping arrangement of Condition 1, the pump would deliver 160 g.p.m. against 155-ft. total head, with the efficiency 55% and 11.3 hp. Power for any of the three cases is well above 10 hp. so that a 15-hp. motor would be required in any of the three conditions. From the standpoint of having an efficient installation there is no question but that Condition 3 should be selected. The combination of characteristic curves on one chart thus presents a fairly clear picture from which to make the best selection for any set of conditions.

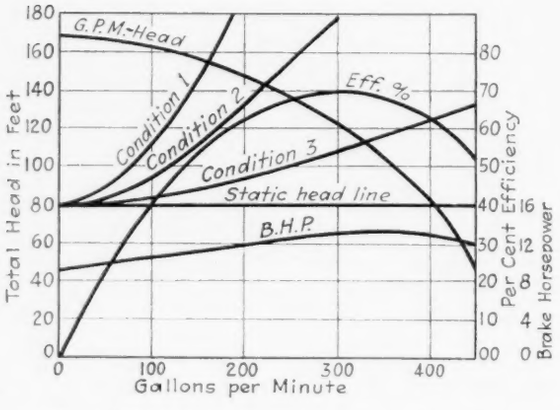


Fig. 5—Pipe-line friction-head curves, Fig. 4, combined with centrifugal-pump characteristic curves, Fig. 1

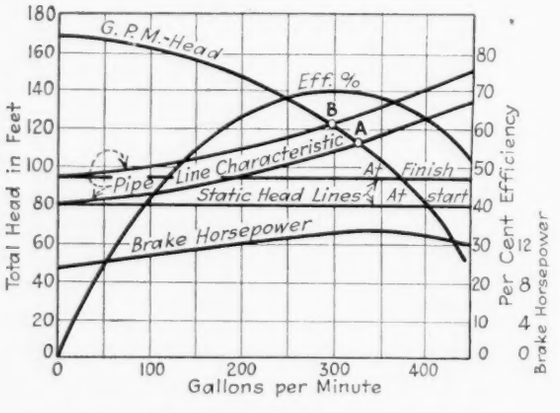


Fig. 6—Pipe-line friction-head curve combined with pump characteristic curves when head is higher at end of pumping than at beginning

It has been assumed in the foregoing example that the level of the liquid in the suction basin and the discharge basin do not change during the pumping period. Let us now suppose that they do change, that the level of the liquid in the suction well drops 4 ft. and that in the discharge basin rises 10 ft. during the pumping period. Thus the static head at the end of the pumping period would be 94 ft. Fig. 6 shows a complete picture of what happens during the entire pumping period with the arrangement that we have called Condition 3.

In Fig. 6, the pump characteristic curves have been included along with two horizontal lines representing the static head at the start and the finish of filling the reservoir. To these have been added the pipe-line characteristic for Condition 3. *A* represents the point on the g.p.m.-head curve at which the pump starts and *B* the point on this curve at which the pump operates at the finish of the pumping period. It indicates that the pump will be operating efficiently during the entire period, and that power consumption will be practically constant.

The example discussed indicates how we may get an accurate graphical analysis of a pumping problem. The same methods may be applied to any type of pumping condition, and present an effective and simple means of selecting pumping equipment. It also gives the purchaser or operating engineer an exact picture of what he will obtain from the pumping system when installed.

Table II—Friction-Head Data for Three Combinations of Suction and Discharge Piping Sizes

Gal. Per Min.	Loss of Head due to Friction per 100 ft. of pipe				Condition 1			Condition 2			Condition 3		
	2½-In.	3-In.	4-In.	5-In.	Suct. Fric.	Disch. Fric.	Total Fric. Head	Suct. Fric.	Disch. Fric.	Total Fric. Head	Suct. Fric.	Disch. Fric.	Total Fric. Head
25	0.92	0.38	....	....	0.3	2.2	2.5	...	...	...	...	...	...
50	3.32	1.38	0.34	....	1.2	7.8	9.0	0.3	3.2	3.5	...	...	...
75	7.0	3.0	0.73	0.24	2.5	16.5	19.0	0.6	7.1	7.7	0.2	1.7	1.9
100	12.0	4.96	1.23	0.39	4.1	28.2	32.3	1.0	12.4	13.4	0.3	2.9	3.2
125	18.5	7.9	1.86	0.64	6.6	43.5	50.1	1.6	18.6	20.2	0.5	4.4	4.9
150	25.8	10.5	2.55	0.88	8.7	60.6	69.3	2.1	24.7	26.8	0.7	6.0	6.7
175	33.5	13.8	3.36	1.18	11.4	78.7	90.1	2.8	32.4	35.2	1.0	7.9	8.9
200	43.1	17.8	4.37	1.48	14.8	101.3	116.1	3.6	41.8	45.4	1.2	10.3	11.5
225	55.0	22.5	5.3	1.86	18.7	129.3	148.0	4.4	52.9	57.3	1.5	12.5	14.0
250	....	27.1	6.72	2.24	....	....	....	5.6	63.7	69.3	1.9	15.8	17.7
275	....	32.3	7.99	2.72	....	....	....	6.6	75.9	82.5	2.3	18.8	21.1
300	....	38.0	9.38	3.15	....	....	....	7.8	89.3	97.1	2.6	22.0	24.6
350	....	....	12.32	4.19	....	....	....	....	....	....	3.5	29.0	32.5
400	....	....	15.82	5.33	....	....	....	....	....	....	4.4	37.2	41.6
450	....	....	19.74	6.65	....	....	....	....	....	....	5.5	46.4	51.9

DIESELS IN BRITAIN—The Annual Report on Heavy Oil-Engine Working Costs, prepared by a committee of the Diesel Engine Users' Assn. of Great Britain, comments upon the changing diesel situation there as the Grid supplies more and more power and the large diesel central stations are operated less and less each year. Diesels are now going to private purchasers instead of utilities, with the result that operating data are harder to get for publication. Costs per kw.-hr. in 52 stations last year show an average of 0.633 lb. of fuel per kw.-hr. over-all, and 2,150 rated b.hp-hr. per gal. of lubricating oil, with average running plant load factor of 68.8%. Crompton, Parkinson, Ltd., showed the low operating cost of 0.334d (English penny equals 2 cents, U. S.) for a 1,125-kw. plant. This plant had a running plant load factor of 70.3%.

WHOSE PATENT?

By Leo T. Parker
Attorney at Law
Cincinnati, Ohio

THE old law was that an employee, as a mechanical or plant engineer, was the sole owner of all patents obtained by him, although he perfected the inventions on the employer's time, and by utilization of the employer's tools and equipment. (229 F. 150.) Until recently it was immaterial that an engineer was hired and paid to improve his employer's product, or business. The employer held a "shopright," which gave him the right to make, sell, and use the invention, but the engineer also was privileged to make, sell and use the invention or to license competitors, and actually owned the patent.

However, in the recent case of Standard Parts V Peck, 264 U. S. 52, the Supreme Court rendered a decision holding that an engineer who perfects an invention, while being paid to do so by his employer, retains *no* legal ownership or interest in the patent.

On the other hand, an employer ordinarily retains no rights in a patent on an invention perfected by an engineer on his own time at his home, or while off duty. This is true although the employee is hired to perform experiments *while on duty* for the purpose of perfecting his employer's product.

In other words, in order to secure exclusive ownership of patents obtained by engineers, the employer or company must include in the contract of employment certain clauses by which the employee expressly agrees to assign patents obtained while in the employment.

For example, in a late case an employment contract contained the following clause:

"In part consideration for the wages now and hereafter paid to said employee by said employer, the employee agrees on demand to assign to said employer, his successors or assigns, the entire right, title, and interest in and to any inventions that he may make during his employment by said employer, or within three months after termination of such employment, which inventions relate to any inventions pertaining to the subject matter of manufacturing or experimental work or tests carried on by said employer during the term of said employee's employment."

It was held that the employer owned all patents obtained by the employee.

The law has been established that an executive, who has not agreed to assign patents to a company, may claim absolute ownership of patents he invents while off duty, yet he cannot use his official position to obtain ideas from company employees and obtain the patents in his own name, nor can he perfect inventions at his employer's expense and claim full title to the patents.

For example, in Wilson V. American Co., 187 F. 840, it was shown that a superintendent made improvements on the machinery used in his employer's plant. The entire cost of his experiments, the perfecting and constructing of the invention was paid by the company.

Robert J. Day in *The New Yorker*. Reproduced with permission

"He has a lot of beautiful ideas, but none of them seem to have borne fruit"

The Court held that the company had a shop right or implied license to use the invention *without payment of compensation to superintendent,* but that the latter owned the patent and could license it to other firms.

It has been held that a confidential manager who obtains patents or inventions *suggested by the company* and also uses the company's materials in perfecting the inventions is not entitled to the patents. (L. R. Eng. 84, 20 Rep. Pat. Case 1.) In fact, various Courts have held that an executive who has the *main responsibility to make the company successful,* may be legally compelled to assign his patents to the company. (254 F. 308.)

Therefore, officials of corporations are expected to render faithful services and, although the company is not entitled to ownership of inventions perfected independently by an official, yet if the latter permits the company to use and sell the patented device, or if he obtains his ideas from company employees, the company owns the patent.

Also, in another case (229 F. 157), it was shown that a vice-president and manager of a plant *at the company's expense* invented and obtained a patent and was instrumental in inducing the company to expend considerable money in tools. The Court held that he could not recover from the company for infringement of the patent, after he left employment.

SPEAKING OF POWER

• A GOOD, warm discussion will do more to clear up a situation than anything else I know about. . . . In January and February *Power* appeared two articles by M. S. Kice on induced-draft fans. He expected some disagreement, and believe me, he got it, particularly on his statement that forward-curved fans will work together successfully in parallel. H. F. Hagen and F. B. Stubinger both took issue with Mr. Kice. We could think of nothing better to do than to give both sides a chance to air their views in the same number, so we promptly sent out copies of the discussions to Mr. Kice. See pages 253-255 for both sides if you're interested in this debate.

. . . fan debate

I suppose almost every engineer likes to hear about queer and unusual power ideas, particularly those that show practical promise. I know I do. . . . The Rupamotor, described on page 258, runs on anything from dried potato peelings to rolled oats. Reminds you of some of the kids on the city streets.

. . . hay, straw

When you make glass, you can't risk a power failure. . . . Pittsburgh Plate Glass figured out that a short power interruption would cost them over a hundred thousand dollars, so they've just completed an emergency gas-engine installation that can take over the load within 15 sec. if the normal power supply should fail. In between, batteries carry the essential load, and of course they start the gas engine too. . . . Read about it on page 259.

Now that I'm home from trouping through Europe its interesting to see many orders already placed for large power units, with many more under consideration. I can't resist the temptation to note that *Power* predicted this situation more than a year ago.

I hope readers concerned with air conditioning found real practical value in the special section last month. Another is coming along shortly (it seems to be a habit). June *Power* will carry a very large section, about 40 pages, devoted exclusively to prime movers—steam engines, turbines, diesel engines, gas engines and hydro turbines. This will be up to the standard of anything we have yet done in the way of a special section. And if we can find any way to make it a little better than that, we shall do so.

prime mover . . .

A basic problem in any institutional or industrial power plant is cost—how much shall various departments be charged? When they use both power and steam in disproportionate amounts, how much should be charged for each? . . . At this point I'm reminded of a building engineer's trick. He was supplying steam to a tenant at a given price, and running the condensate back to his boiler-room without credit. The tenant heard someplace that hot condensate was worth money and demanded credit for it on his steam bill. So our friend carefully put a water meter on the condensate line, but secretly ran another condensate line up through the wall. Each month he opens the metered line long enough to register a little on the meter, but most of the condensate still comes back to him for nothing. . . . R. H. Sogard, page 247, shows how steam and electric costs are allocated at the University of Missouri, where it is all in the family and secret condensate lines are taboo.

One thing that struck me when I opened the April number was the number of "tops" going into power stations. Apparently most of the central-station engineers have decided that this is the best way to kill two birds with one stone, to increase capacity and raise over-all efficiency at the same time. The fact shouldn't be overlooked that the same trick could be worked in many an industrial plant. It has already been used in several with marked success.

more tops . . .

News of the floods was, of course, in the European papers, but I didn't realize the full extent of the disasters until I came home. I hope that the articles on drying out equipment, which *Power* mailed to all of its subscribers in the flooded districts, were helpful in the emergency. It wasn't possible, on such short notice, to take care of everybody involved. In fact we couldn't very well know just which plants were flooded, beyond the few that came directly to our attention. Fortunately, some of those concerned, who did not get the reprints directly, saw our notice on page 212 of April *Power* and wrote in for them.

Coming home on the "Europa" I became quite friendly with an Irish engineer who was returning to a job in New York after spending about 4 years in a German-operated beet-sugar factory in Dublin. Said this Irish engineer to me: "There was a Czechoslovakian working in that German factory in Ireland, and he told me he subscribed to *Power* because it was the best power magazine published in Germany."

red light . . .

Here's another one: In Berlin I crossed a street against a red light. The cop didn't see me (saving one mark), but a citizen did and gave me a reproving look. Using my pet phrase for all such emergencies, I said "Ich kann nicht viel deutsch sprechen." "But you know the difference between a red and a green light, don't you?" That's logic in any language.

PHIL SWAIN
Editor

Resolution

Whereas,

Fred R. Low

past President of the American Society of Mechanical Engineers and for many years Editor of the Journal of Commerce and of Power has passed on. Now, therefore, Rhode Island Assn. No. 1, National Assn. of Power Engineers in recognition of his service to the engineering fraternity, his unceasing efforts for its advancement and his sterling qualities and marked abilities, hereby express our deep regret at his passing and the loss to the fraternity of a man whose real worth was so evident to us all.

Rhode Island Assn. No. 1
National Assn. of Power Engineers.

By Committee

Leon J. Adams

Alexander Ferguson

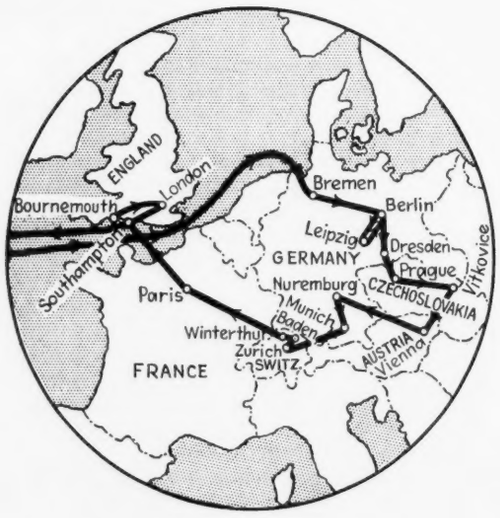
Ralph L. Blackman

February 8, 1936.

RECOLLECTIONS

By Philip W. Swain

Editor of POWER



DETAILED reports of my editorial jaunt through six European countries will trail along for several months, so perhaps I should set down a few over-all impressions while they are still warm.

My most vivid recollections are of Germany, partly because I stayed there longest (20 days) and partly because I think it is intrinsically one of the most interesting countries in the world. My Leipzig Fair report appeared in *Power* last month, and an account of some of my experiences and findings in Berlin and Leipzig will be found on page 244 of this number.

Liveliest German memories are: spotless towns and country-side, the spirit of workmanship in all things, unbounded courtesy and hospitality, the smoothness of Berlin, the activity of Leipzig, the stateliness of Dresden, the quaint charm of Nuremburg, the exuberant life of Munich, friendly contacts at the V.D.I., 20,000-r.p.m. turbine at the A.E.G. factory, Benson boiler at Siemenstadt, my speech at V.D.I. and broadcast from Berlin.

Czechoslovakia brings to mind ancient and wonderful Prague, and hardworking Vitkovice—the latter garnished with Loeffler boilers, steel works, coal mines, goat's meat and Pilsener beer.

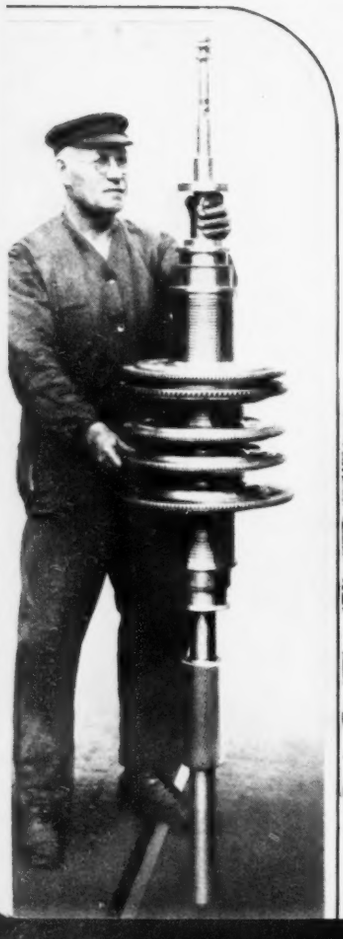
Austria will be remembered for mountain villages and for the hearty whole-souled people who live in those villages and in the fair city of Vienna—also for business that is too quiet for economic comfort.

It is hardly necessary to say that I liked Switzerland. Who couldn't? Take a little patch of fairyland, sprinkle with rocky peaks, lovely lakes and chalets. Forget to add iron or coal, but people the land with folks who will make up this deficit with ingenuity and hard work. Let the whole mass come to a boil with well-directed energy; then cool and serve garnished with cheese, ski jumpers and clean cities. That is Switzerland (with due apologies to Fanny Farmer). As an engineer, I remember Switzerland also for very snappy machinery—Velox boilers, turbo blowers, steam turbines, water turbines, diesel engines.

France, I am sorry to report, seems to be marking time in engineering matters. My best memories there are not so much of Paris of this year as the backwoods' contacts of 1918—friendly peasants in the Auvergne and likeable "poilus" along the St. Mihiel front.

Landing finally in England, I was agreeably surprised to get back again to a country that speaks my own language, approximately. What I saw in seven days was chiefly London—and that is plenty! Don't misunderstand me! I mean "plenty nice," to use an expression of which no Englishman would approve. From London I bring the good news that the power-equipment makers are loaded to the gills with orders, that new power stations and additions are popping up everywhere and that the good old town itself is God's gift to homesick folks—a friendly, homelike place (and don't believe anything you may hear to the contrary).

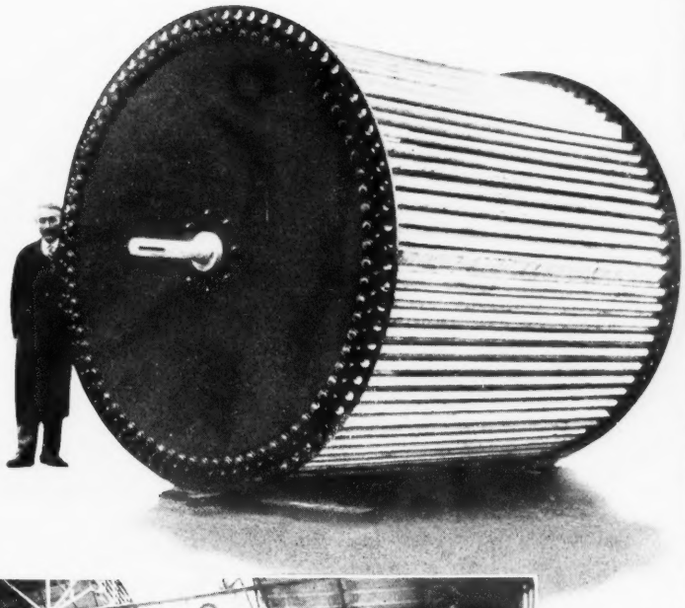
There is my personal picture of Europe in a few inadequate words. For further details see the articles.

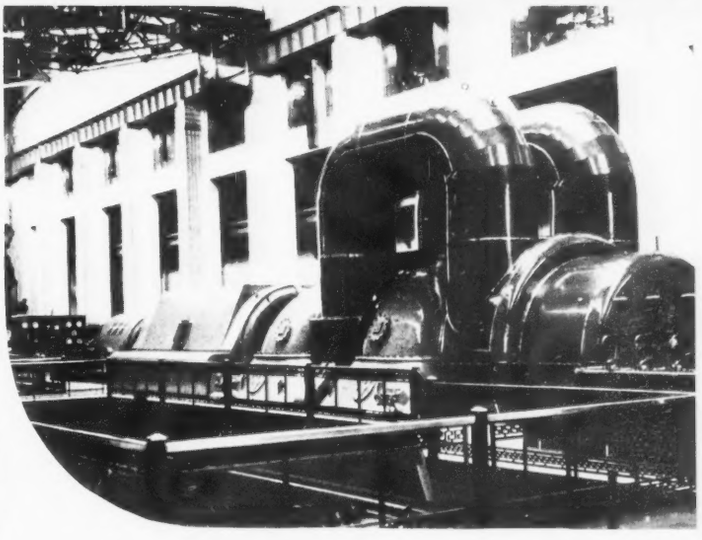


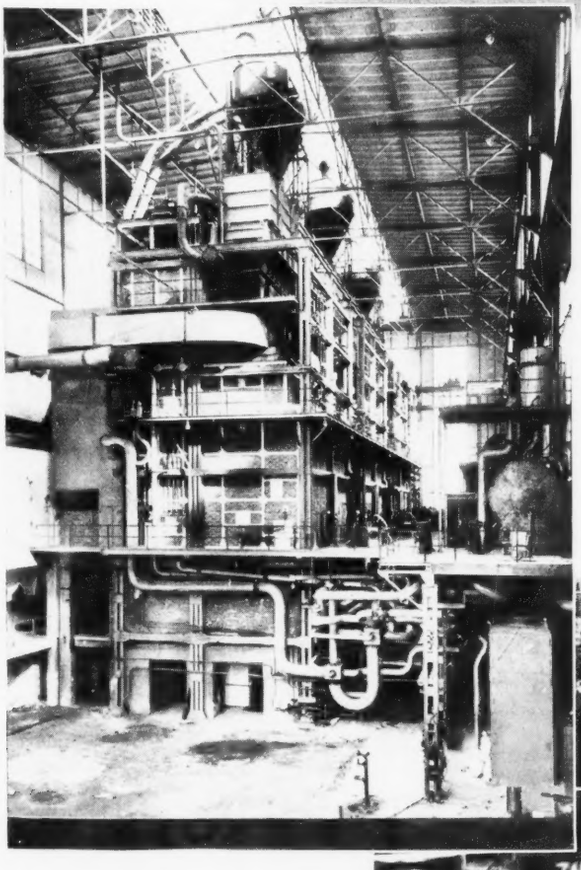
Left—One ponyweight delivers 1,000 hp. at 12,000 r.p.m. Speed puts metal to work in this A.E.G. turbine (Berlin)

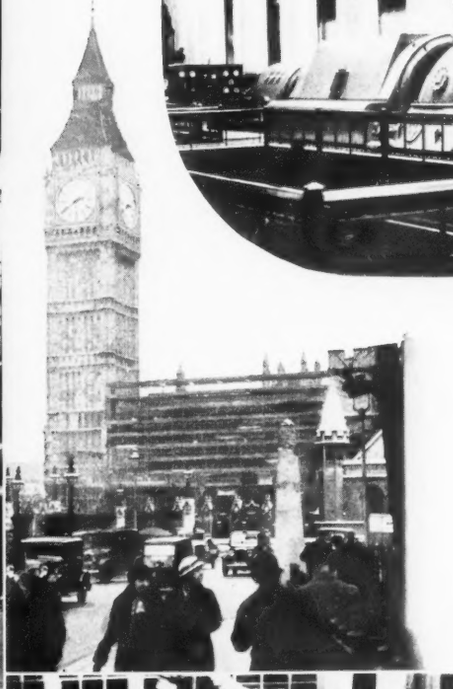
Left—Old Nuremburg, home of great craftsmen since the Middle Ages, today produces ultramodern power machines, steam and diesel

Right—Battersea's plume is not smoke, but water vapor. Dirt is all scrubbed out. This great London plant has Europe's largest steam turbine—100,000 kw. (below right). Below—France washes flue gas by passing it through nests of tubes rotated in contact with a water pan

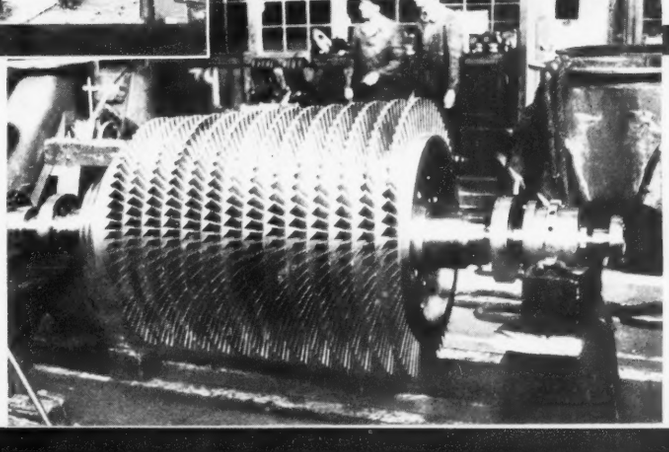








Far Left—Three Loeffler boilers in Trebovice plant, Czechoslovakia. Below—Note the airfoil blades in this turbine blower in the Brown Boveri factory at Baden, Switzerland. Left—Big Ben, dear to the heart of every Londoner



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Head Loss in Ft., Due to Water Friction, Per 100 Ft. of 15-Year-Old Ordinary Iron Pipe

Gal. Per Min.	0.5-In. Pipe		0.75-In. Pipe		1-In. Pipe		1.25-In. Pipe		1.5-In. Pipe		2-In. Pipe		2.5-In. Pipe		3-In. Pipe		4-In. Pipe		5-In. Pipe		6-In. Pipe		7-In. Pipe		8-In. Pipe		10-In. Pipe		12-In. Pipe		14-In. Pipe		16-In. Pipe	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
1	1.05	2.1																														
2	2.10	7.4	1.20	1.9																												
3	3.16	15.8	1.80	4.1	1.12	1.26																										
4	4.21	27.0	2.41	7.0	1.49	2.14	0.86	0.57	0.63	0.26																						
5	5.26	41.0	3.01	10.5	1.86	3.25	1.07	0.84	0.79	0.40																						
10	10.52	147.0	6.02	38.0	3.72	11.7	2.14	3.05	1.57	1.43	1.02	0.50																				
15			9.02	80.0	5.60	25.0	3.20	6.50	2.36	3.0	1.53	1.08	0.98	0.36																		
20			12.03	136.0	7.44	42.0	4.29	11.1	3.15	5.2	2.04	1.82	1.31	0.61	0.91	0.25																
25					9.30	64.0	5.36	16.6	3.94	7.8	2.55	2.73	1.63	0.92	1.13	0.38																
30					11.15	89.0	6.43	23.5	4.72	11.0	3.06	3.84	1.96	1.29	1.36	0.54																
35					13.02	119.0	7.51	31.2	5.51	14.7	3.57	5.1	2.29	1.72	1.59	0.71	0.89	0.17														
40					14.88	152.0	8.58	40.0	6.3	18.8	4.08	6.6	2.61	2.20	1.82	0.91	1.02	0.22														
45							9.65	50.0	7.08	23.2	4.60	8.2	2.94	2.80	2.05	1.15	1.15	0.28														
50							10.72	60.0	7.87	28.4	5.11	9.9	3.27	3.32	2.27	1.38	1.28	0.34														
70							15.01	113.0	11.02	53.0	7.15	18.4	4.58	6.21	3.18	2.57	1.79	0.63	1.14	0.21												
75									11.80	60.0	7.66	20.9	5.01	7.0	3.4	3.0	1.92	0.73	1.22	0.24												
100									15.74	102.0	10.21	35.8	6.54	12.0	4.54	4.96	2.55	1.23	1.63	0.41	1.14	0.14										
125									19.50	151	12.75	54.0	8.16	18.5	5.67	7.9	3.19	1.86	2.04	0.64	1.48	0.28										
150											15.32	76.0	9.80	25.8	6.8	10.5	3.84	2.55	2.45	0.88	1.71	0.32	1.25	0.17								
175											17.85	102.	11.3	33.5	7.94	14.0	4.45	3.44	2.86	1.18	2.00	0.48	1.45	0.23								
200											20.4	129.	13.07	43.1	9.08	17.8	5.11	4.40	3.27	1.48	2.28	0.62	1.66	0.28	1.28	0.15						
225													14.71	54.3	10.2	22.3	5.77	5.45	3.67	1.86	2.57	0.74	1.86	0.34	1.44	0.18						
250													16.3	66.0	11.32	27.2	6.40	6.72	4.08	2.24	2.80	0.92	2.07	0.42	1.60	0.22						
275															12.50	32.5	7.03	7.99	4.50	2.72	3.06	1.15	2.30	0.51	1.73	0.27						
300															13.62	38.0	7.66	9.30	4.90	3.14	3.40	1.29	2.49	0.60	1.90	0.32						
350																	8.90	12.32	5.72	4.19	3.98	1.75	2.95	0.80	2.20	0.42						
400																	10.21	16.00	6.54	5.40	4.54	2.21	3.36	1.03	2.60	0.54						
450																	11.50	19.80	7.35	6.70	5.12	2.65	3.75	1.25	2.92	0.68	1.80	0.21				
475																	12.20	22.96	7.76	7.42	5.55	2.95	4.43	1.72	3.10	0.76	1.94	0.25				
500																	12.77	24.00	8.17	8.12	5.60	3.30	4.14	1.64	3.20	0.82	2.04	0.28	1.42	0.11		
550																	14.04	28.7	8.99	9.60	6.16	3.93	4.55	1.81	3.52	0.97	2.25	0.33	1.57	0.14		
600																			9.80	11.30	6.72	4.70	4.97	2.09	3.84	1.14	2.45	0.39	1.71	0.15		
650																			10.62	13.20	7.28	5.40	5.39	2.45	4.16	1.34	2.66	0.46	1.85	0.19	1.37	0.09
700																			11.44	15.10	7.84	6.20	5.80	2.83	4.46	1.54	2.86	0.52	2.00	0.22	1.47	0.10
750																			12.26	17.20	8.50	7.00	6.21	3.21	4.80	1.74	3.06	0.59	2.13	0.24	1.58	0.11
800																			13.07	19.40	9.08	8.00	6.62	3.58	5.12	1.97	3.28	0.67	2.27	0.27	1.68	0.13
850																			13.89	21.7	9.58	8.95	7.04	4.06	5.48	2.28	3.48	0.75	2.41	0.31	1.79	0.14
900																			14.71	24.00	10.30	10.11	7.46	4.54	5.75	2.46	3.68	0.83	2.56	0.34	1.89	0.16
950																					10.72	10.80	7.88	5.02	6.06	2.87	3.88	0.91	2.70	0.38	2.00	0.18
1,000																					11.32	12.04	8.28	5.5	6.40	3.02	4.08	1.01	2.84	0.41	2.10	0.19
1,050																					11.90	13.30	8.47	5.76	6.70	3.21	4.29	1.09	2.98	0.44	2.20	0.22
1,100																					12.50	14.31	8.69	6.04	7.03	3.51	4.50	1.20	3.13	0.49	2.31	0.23
1,150																					12.95	15.60	9.31	6.36	7.35	3.84	4.71	1.34	3.27	0.53	2.42	0.25
1,200																					13.52	16.69	9.93	7.69	7.67	4.15	4.91	1.46	3.41	0.57	2.52	0.26
1,250																					14.10	18.50	11.22	9.62	8.00	4.45	5.11	1.55	3.55	0.62	2.63	0.29	1.99	0.15
1,500																					17.02	25.60	12.42	11.65	9.60	6.27	6.10	2.09	4.20	0.85	3.15	0.39	2.39	0.21
2,000																							16.56	19.92	12.70	10.71	8.10	3.65	5.60	1.43	4.20	0.66	3.19	0.39
2,500																									15.80	15.15	10.10	5.33	7.00	2.28	5.25	1.01	3.99	0.56
3,000																											12.10	7.80	8.40	3.15	6.30	1.47	4.79	0.80
3,500																											14.10	10.08	9.80	4.10	7.35	1.81	5.59	1.04
4,000																													11.35	5.32	8.40	2.47	6.38	1.35
4,500																													12.78	6.90	9.45	3.22	7.20	1.6
5,000																													14.20	8.40	10.50	3.92	7.96	2.02
5,500																															11.55	4.65	8.78	2.39
6,000																															12.60	5.50	9.56	2.60
6,500																															13.65	6.45	10.36	3.32

Vel. = Water velocity in pipe in feet per second

Fric. = Feet head loss due to pipe friction

Friction loss values based on Williams & Hazens formula;

$$S = \left\{ \frac{V}{1.318\ CR^{0.63}} \right\}^{1.85}$$

Where S = Friction loss in feet head per foot of pipe.

V = Flow velocity in feet per second.

C = Constant depending on condition and kind of pipe. In the table, C = 100.

H = Hydraulic radius of pipe = pipe inside diameter in feet ÷ 4.

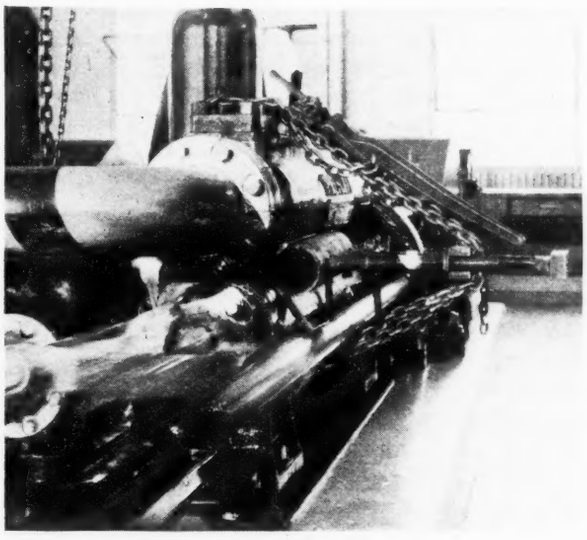
Example—A flow of 100 g.p.m. in a 2-in. pipe produced a velocity of 10.21 ft. per sec. and a head loss of 35.8 ft.

Feet of Straight Pipe to Which Fittings are Equivalent

Diam. Inches	Standard Elbow	Long-Radius Elbow	Globe Valve	Gate Valve
0.5	1	0.5	3	0.4
0.75	1.5	0.75	5	0.6
1	2	1.2	6	0.8
1.25	3	1.5	9	1.2
1.5	4	2	11	1.5
2	5	2.5	14	2
2.5	6	3	18	2.8
3	8	4	24	3
4	11	5.5	32	4.2
5	15	7	42	5.5
6	18	9	52	7
7	20	10	60	8
8	24	13	75	10
10	32	16	100	13
12	40	20	125	16
14	48	24	150	19
16	58	29	175	22

Example:—Head loss through a standard 2-in. elbow is equivalent to 5 ft., a long-radius elbow to 2.5 ft., a globe valve to 14 ft., and a gate valve to 2 ft. of straight pipe.

PRACTICAL AIDS TO OPERATION



Make Emergency Pump Repair With Chain and Pipe

A CURIOUS type of failure became evident in one casting of a duplex-plunger pump, 24- x 4½-in. plungers working against a line pressure of 900 lb. per sq.in. On his usual round of the station, the engineer noticed that the casting wall was bulging out with each pumping stroke of the outboard plunger, and regaining its normal position as the plunger started on the suction stroke. Measurement of this breathing motion showed it to be 0.375 in., in what was supposed to be a rigid wall of steel.

Telegraphic word to the pump manufacturer brought the message that there was no corresponding casting in stock and that it would require two or three weeks to ship a new one. Shutting the pump down for that length of time was a last resort only and as it was not feasible to disconnect the damaged side and run half of the pump, some type of repair was imperative. As the break was internal, there was nothing to weld on or braze to give added strength.

The engineer surmounted the difficulty by taking a short length of 4-in. extra heavy pipe, welding a series of transverse braces within it. He then clamped this pipe in place with a series of wrappings of chain, the loops being long enough to pass over cross braces carried on the ends of long 1¼-in. rods welded to the 4-in. pipe block and threaded to permit tightening of the chains.

As much slack as could be taken from the chains was pulled up with the usual type of oil-field boomers, and then the adjusting nuts screwed outwardly to put tension in the chain. This strain was evened as closely as possible, the pull on each strand being determined by striking the chain lightly with a bar of steel. Adjusting was done until the chains all tuned alike, that is, gave the same note on being struck. The pump was again started, and pressure gradually built up to the normal line value and it was found that the breathing action had been reduced from 0.375 to 0.025 in., evidence that the chains were successfully carrying the load.

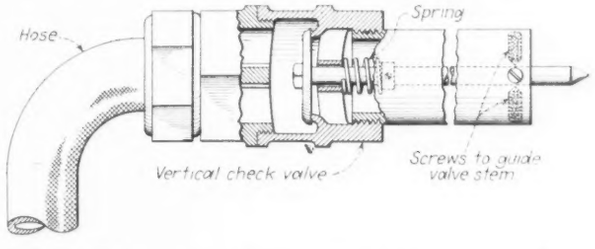
So well was this emergency repair made that the pump continued to deliver its rated output for 29 days, until the new casting arrived and it was possible to shut down and replace the damaged unit. Investigation of the faulty casting showed a hair-line crack in the pump barrel working gradually upward toward the valve chamber. During the month's operation after being first observed, the crack had gradually extended until it severed the wall between two adjacent valve seats. Extent of the cavity within the casting was illustrated by the gradual seepage of fluid into the barrel for weeks after the casting was replaced.

Longview, Texas — ELTON STERRETT

Make Core-Filler Valve From Vertical Check Valve

BEING in need of a core-filler valve in our ice plant, I made one from ¾-in. vertical check valve, as in the figure. I removed the stem from the valve disk and 4 ft. of ¼-in. rod attached for operating the valve. A 3-ft. length of pipe was threaded into the lower end of the valve, with three screws, 120 deg. apart, threaded into its bottom end to act as a guide for the valve rod. A spring held in place by a collar on the rod insures quick closing.

In use, the filler is inserted into the core until the valve stem bottoms and the valve is forced open. When the core



is filled, lifting the valve stops the flow automatically. If water pressure is high, this valve would be quite hard to open because of the pressure holding it on its seat. In the case described water pressure was only 10 lb. per sq.in., consequently loading on the valve was comparatively light.

Cleveland, O. — FRED W. SCHNEIDER

External Corrosion Damages Boiler-Head Sheet

BOILERS remaining out of service for short periods of time are subject to rapid external deterioration unless every precaution is taken to avoid corrosive conditions. Absolute cleanliness of all heating surfaces is essential and steam or water leakage into the setting or on pressure parts must be guarded against. Consequences of disregarding these precautions may well be illustrated by a recent happening.

An engineer, while visiting a small laundry power plant, was asked to examine a leak in the rear head seam of a dry-back scotch marine boiler. It seems that the leakage had been going on for a considerable period and had suddenly become worse. On the day preceding the engineer's visit, an attempt was made ot fire up the boiler. The fireman, noticing increased leakage as the boiler was coming up to pressure, removed the fire and allowed the unit to cool down.

Before examination of the leaking seam was possible, it

was necessary to remove a large quantity of soot banked against the lower section of the head sheet. This material was caked to such an extent as to require a good deal of punching with a bar to effect its removal. While engaged in this work, the fireman accidentally struck the sheet with the end of the bar and it passed through the metal and into the boiler.

Further examination revealed that corrosion due to soot and water in contact with the metal had dangerously reduced the sheet thickness over a considerable area. This boiler was alternated in weekly service with another unit, and had carried full pressure of 110 lb. only a week before.

Waynesboro, Va. S. H. COLEMAN.

Stops Leakage From Brass Pipe Thread

TROUBLE from leakage at threaded connections is often encountered when using brass pipe. It has been found that wrapping cotton thread or light string around the root of the threads usually assures a leak-proof connection. Soft cotton thread should be used with pipe up to $\frac{3}{4}$-in. in diameter, and light, soft string for larger sizes. The thread or string is soaked in white lead and is wrapped around the root of the pipe thread for its entire length. In making up the joint, this has a grommet effect and wedges into any crevices or damaged places in the threads.

Chicago, Ill. R. O. BILLINGS

Cut Oil Costs 60% By Separators

WHEN I took charge of the Cincinnati General Hospital power plant, I found a number of drips that carried considerable oil to the sewer. From past experience in saving oil in other plants I decided that it was possible to recover much of it. The maintenance crew were therefore put to work building and piping up an oil separator, Fig. 2, to catch the drips from the engines and other units in the plant. The three engines are of the corliss type and drive 250-kw. d.c. generators.

These engines, one shown in Fig. 1, have a splash plate X that is intended to return oil to the crankcase. Drips from the piston rod dropped down ahead of this plate and were piped to the sewer. It was found that oil was thrown over the splash plate and went to the sewer with the piston-rod drips.

Other separators were erected under the oil separators in the exhaust steam lines, and a considerable amount of cylinder oil recovered.

In 1926, 1927, and 1928, there was purchased a total of 55, 50 and 51 bbl. of cylinder and engine oil at a cost of $703, $662 and $667 respectively. Since that time the oil consumption per year has averaged only 22.7 bbl. at an average cost of $318. The amount of oil purchased had been gradually decreasing, and last year it dropped to 16 bbl. costing $276. From this it will be seen that by installing oil separators to recover oil that otherwise went to the sewer and by keeping careful records of oil used it has been possible to reduce the purchase of new oil by over 66%, a saving of $400 per year.

Cincinnati, O. ANTHONY A. FETTE,
Chief Engineer,
Cincinnati General Hospital

Quick Repair to Engine Foundation

ONE day it was reported that the outboard bearing on a 180-hp. engine was running hot. Investigation showed movement in the upper part of the foundation supporting the bearing, on a line approximating the position of the holding plates on the anchor bolts. The foundation was masonry, and it was decided to replace the defective part with concrete.

The 18-ft. flywheel weighs about 5 tons. In the absence of a crane it was lifted with two jacks, bearing against a wood block cut to fit the wheel. The pillow block bolts were loosened and the jacks operated to lift the crankshaft level.

To fix this position by measurements so that it could be duplicated after the cement foundation was poured was the next problem. A corner of the engine room was not far away. A steel plate with a light center punch mark was set into each wall and two center punch marks were then made

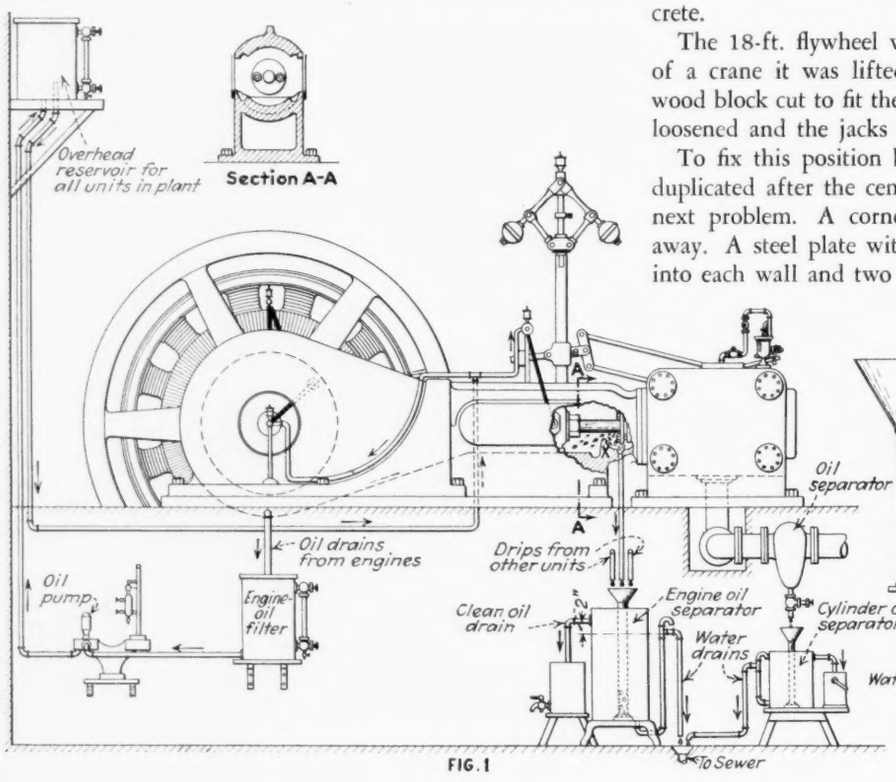


FIG. 1

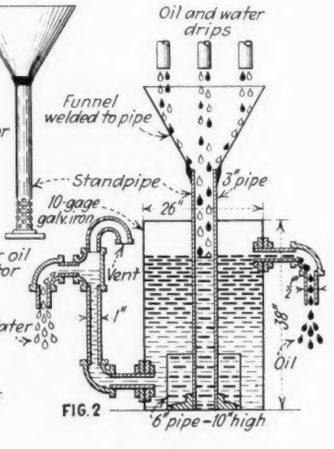
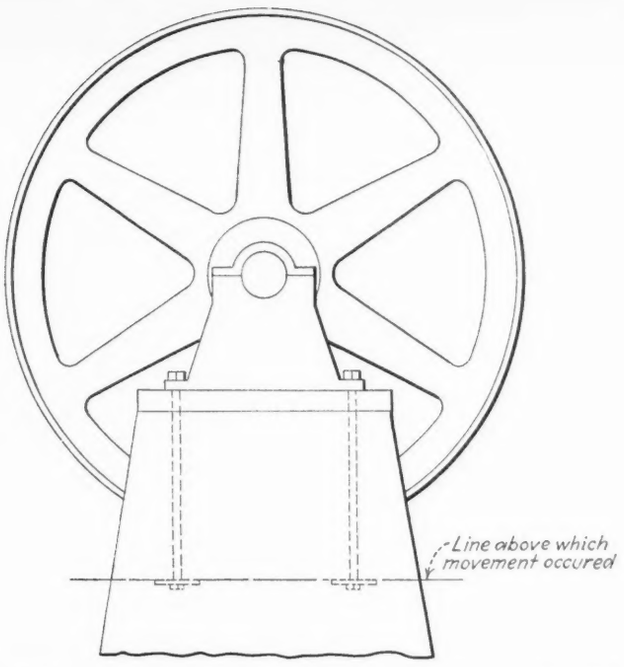


FIG. 2



in the pillow-block casting. Two pointed measuring rods were then made and marked, each rod being exactly as long as the distance from the center punch mark on a wall plate to its corresponding center-punch mark on the pillow-block casting. This established exact position of the pillow block, the level shaft giving the height.

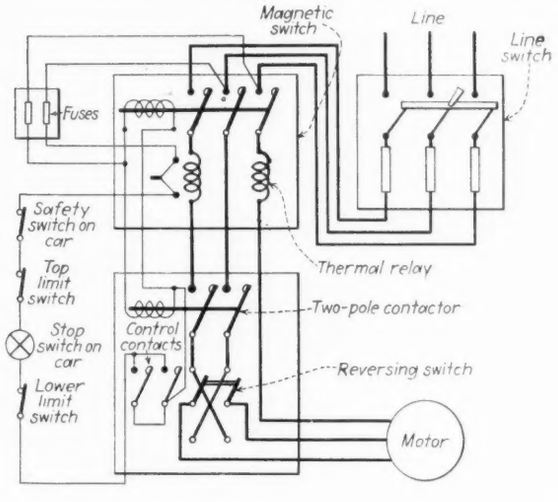
Tearing down the old masonry was started at noon on Saturday. Quick-drying cement was used in the concrete. Everything worked out all right, and the factory was running on Tuesday morning.

St. Mary's, Ont. J. D. RELYEA

Change in Control Connections Prevents Fuses Blowing

THE figure shows a wiring diagram for a manually controlled freight elevator driven by an 8.5-hp., 3-phase, 440-volt motor. The reversing switch and the control contacts are open and closed mechanically by the control cable. To prevent breaking the circuit on the reversing-switch contacts the control contacts open before the reversing switch and close after they close.

Trouble was experienced with two of the line fuses blowing simultaneously. Originally only the 2-pole contactor



closed and opened the circuit for starting and stopping the elevator. The cause of fuse blowing was found to be severe arcing on these two contacts, developing into a short circuit. To prevent this arcing, the coils of the two-pole and three-pole magnetic switches were connected in parallel as in the figure. These switches now close and open simultaneously and insure complete interruption of the circuit under any condition of load. Making this change in the controller eliminated fuse failures.

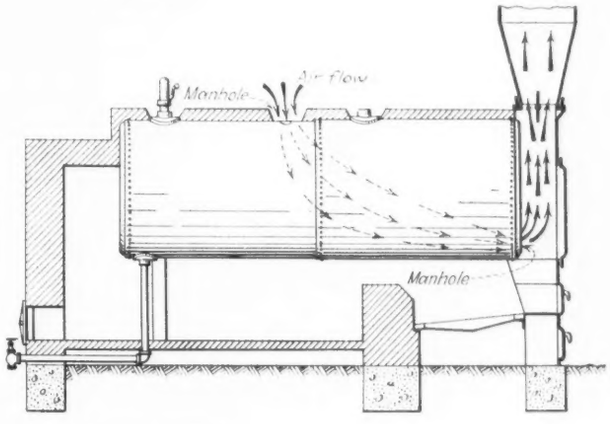
Oakland, Calif. RALPH BARR GLEN

Welds Anchor Bolt in Place on Engine

A 1.5-in. anchor bolt holding down an engine broke off flush with the top of the base casting. We could not shut down long enough for the anchor bolt to be replaced. The small clearance space betwen the bolt and the side of the hole was first cleaned out. A strip of thin mica was fixed in the clearance space to surround a bolt, and extended half an inch above the top side of the casting. Then the end of the bolt was built up to the top of the mica with an oxy-acetylene torch, using a high-test steel welding rod. The mica prevented the weld metal joining to the casting. The threaded part of the bolt, which had broken off, was then welded to the built-up bolt.

To avoid the necessity of cutting threads in the built-up section, a thick washer was put on it and the nut screwed down. The bolt was found to have ample strength, and since then has given satisfaction and is still in use.

Bromley, England W. E. WARNER



Stack Vents Boiler During Inspection

A STUNT that I have used when inspecting and cleaning a horizontal-tubular boiler is shown in the diagram. The top and rear end manhole plates are taken off, all furnace and ash doors are closed and the damper is opened. This permits the stack to draw a current of fresh air through the boiler as indicated by the arrows and permits a man to enter a boiler even before it has cooled.

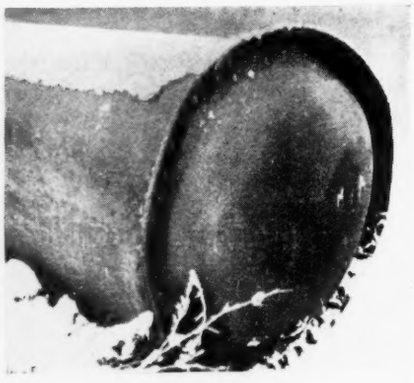
Dayton, O. E. D. BEISER

Keeping Fuse Labels Clean

MANY engineers have difficulty in keeping labels clean on fuses and on boxes of packing, so that they can be easily read. I have solved this problem by painting them with clear shellac or a transparent cement.

Cleveland, O. FRED W. SCHNEIDER

CURRENT COMMENT



Excessive Air Pressure Reverses Receiver Head

THE photographs in the article, "Why Compressed Air Explosions," March *Power*, illustrate some of the things that happen with compressed air. This photograph gives another example. In this case the tank was used as an air receiver on a system where the pressure was far in excess of that for which the tank was designed. The concave head of the tank reversed and became convex as in the photo. Fortunately, in doing so the riveted joint opened up and relieved the air pressure before the tank exploded. No harm was done other than destroying the tank.

Wausau, Wis. CHARLES LEIGHTON

More Errors in "What's Wrong Picture"

IN THE March *Power*, Page 163, a sketch of a boiler is given and on the following page we are told what is wrong with it. Many errors were not mentioned, so I am passing on some more defects. I do not claim these are all the errors. The picture gives us the idea that the boiler is in actual operation, and I shall follow this in listing additional errors:

No water or steam in the boiler

Boiler should be provided with two means of feed

Boiler cannot operate without a water column which should be drained and piped to safety

Boiler should have water glass which should be drained and piped to safety

Boiler should have three gage cocks

Main steam line should be anchored and supported

Safety valve body should be drained

Access doors should be provided in the setting

Should boiler have a bridge wall?

Feed line should be carried through shell with flange or bushing and be piped back in the boiler at $\frac{2}{3}$ the length of the boiler from the front, said piping to be supported or braced and not discharge near seams.

Boiler should be supported by hangers or brackets

Do you consider proper type of combustion chamber arch has been shown and will be safe?

Blowoff pipe and safety valve discharge should be piped to safety

Why not have two safety valves? It is fair to assume that the boiler having a 4½-in. safety valve really needs two safeties.

Is blowoff piping extra heavy steel?

Are fittings in blowoff line extra-heavy and steel?

Should boiler have manhole below tubes?

Tubes do not show beading. Is it necessary?

Safety valve drain should be piped from top of boiler to safety.

Drain between double stop valves should be piped to safety yet have end visible to operator

Should stop and check valves on feed line be closer to boiler?

Should not an automatic low water control be provided inasmuch as oil is used as a fuel?

Should cutout be used to control oil burner in case of low water?

Where are gases or products of combustion shown leaving the combustion chamber or stack?

Where can 4½-in. blowoff lines be used? If the 4½-in. line to hot-water faucets is as shown, it is fair to assume the blowoff line is also 4½ in.

CHARLES W. CARTER, JR.
Binghamton, N. Y.

In the original drawing, the intention was to show certain things most commonly done wrongly, simplifying the sketch as much as possible to emphasize these things. For that reason, no water level nor "steam in production" were shown. However, Mr. Carter has brought up a number of interesting points, some of the more obscure of which deserve further discussion—Editor.

Electric Welding Repairs Manhole Flange

I HAVE read, "Electric Welding Repairs Manhole Flange," by A. C. Wiggins in March *Power*, and suggest that care should be exercised when following the practice outlined, as I doubt if it would be passed by inspectors for pressures in excess of 15 lb. The author states that the method is satisfactory for low-pressure heating boilers up to about 25 lb. This is not in accordance with the New York State Boiler Code, which puts boilers for more than 15 lb. pressure in the power class.

The article suggests that the plate welded to the manhole should have a thickness about equal to that of the tube sheet. The Code requires that patches have a thickness not less than that of the tube sheet. Why could not a flanged manhole be installed, especially since the pressure is in excess of 15 lb?

The A.S.M.E. Boiler Code allows an area of 100 sq.in. to be deducted from the area stayed, where a manhole opening is properly formed. The Code reads: "Where a manhole has a flange which has been formed from the solid plate and turned inward to a depth of not less than 3 times their required thickness of the head, measured from the outside, the area to be stayed as indicated in Fig. *P*-19 may be reduced by 100 sq.in." Removing the flange from the old tube sheet seriously weakens it in this area. I am wondering if it is considered safe not to stay this area?

CHARLES W. CARTER, JR.
Binghamton, N. Y.

The foregoing letter was submitted to A. C. Wiggins and the following is his reply. —Editor.

IT IS true that New York State Code classes boilers operating at over 15 lb. pressure, power boilers. There are other states not operating under the same code as New York State, and states not under any code at all. For example, an extract from the Massachusetts Boiler Rules; Part II, Section 1, states: "The pressure allowed on a boiler constructed entirely of cast iron, with the exception of the connecting bolts and nipples, and installed within this Commonwealth on or before July 2, 1915, shall not exceed 25 lb. per sq.in." For later installations the pressure is limited to 15 lb. A cast-iron boiler is considered a low-pressure boiler.

In any state, the main point is safety. In states which have not adopted boiler codes, this is looked after rigidly by boiler-insurance inspectors, in those boiler plants that are insured. The repair job described in March *Power* was recommended by an authorized boiler inspector for a 25-lb. boiler in a non-code state, and approved in consultation with several other code-state, commissioned inspectors.

The manhole flange was welded in an H.R.T. boiler that was about 30 yr. old. The maximum planned life of the boiler was to be 35 yr., and the expense of purchasing a fabricated, flanged plate and riveting it in was not economical, especially where the boiler was for heating, and it was to be replaced in a few years. The expense was certainly not warranted where the present repair is safe.

In regard to the quotation from the A.S.M.E. Code permitting the deduction of 100 sq.in. for a manhole flange: This paragraph, P-218, specifically states that this requirement is for below the tubes in an h.r.t. boiler only. The repair job in question is *above* the tubes. For simplicity and clearness in the sketch, the bracing was not shown. The staying was calculated and found sufficient to meet safely the limit of allowable stresses at the boiler's working pressure.

Cleveland, O. A. C. WIGGINS

Curved Versus Flat Bridge Walls

IN FEBRUARY *Power* Bunyan Kennedy states, "Let's hear from one who knows."

Yes, sir, Mr. Kennedy, you were right to take a stand about midway between the two men who gave their ideas on bridge-wall construction. Even then you were all wet as far as the modern theory and practice of combustion principles are concerned.

An open deteriorated bridge wall will permit the particles of combustible and volatile gas to flow more easily, but—too much excess

air is allowed to pass. Air that enters through the grates continues on from the firebox, to the combustion chamber, then up the stack. Orsat readings taken in various places in the firebox for O_2, CO_2 and CO indicate that the main volume of fire and unburned gas follows through the center of the firebox and combustion chamber; the excess air travels outside of the flame; that is, enveloping the body of gas on both sides, over, and underneath the fire. Unburned gas, carbon, and smoke pass up the stack unconsumed, together with the surrounding excess air. Therefore, even though an exorbitant amount of excess air is present, the furnace will smoke. If this opening between the firebox and the combustion chamber is restricted similar to the venturi tube in an automobile carburetor, a steam injector, or ejector, then the air and volatile gases are forced to mix more thoroughly, thus permitting complete combustion with a minimum of excess air.

The semicircular restricted opening 8 in. below the shell of the boiler is also wrong for several reasons. Proper combustion to burn the CO to CO_2 must take place in an area hot enough to complete combustion; a temperature of about 1,800 deg. is satisfactory. This degree of heat cannot be expected next to a boiler shell that has a surface temperature around 450 deg. at 100 lb. steam pressure. The fact is, wood or wood refuse with a natural moisture content around 40 or 50% will not burn successfully at high ratings in any firebox type boiler where the firebox is surrounded with bare water walls. The cooled gas next to the shell passes through the combustion chamber unconsumed. If the fuel is dry and a hot fire is burning in the firebox, then this design will disrupt the natural circulation of water in the boiler, and cause scale to be deposited on the area where the intense heat strikes the bottom of the shell. Then comes the "bulge," and then what? This condition exists with the extended type of Dutch-oven fireboxes, also on fireboxes built directly under the boiler.

The proper solution to the problem is the installation of a modernized drop-nose arch furnace with the bridge wall located far enough ahead so that the drop-nose projects the fire down, and away from the boiler shell as illustrated. If a sprung arch is used, then add more courses of brick, and design the additional arch so that it projects the fire downward. This arrangement will permit only radiant heat to strike the shell when heavily fired. Most of the soot and unburned cinders will be deposited on the floor of the combustion chamber where they will eventually burn. The rear end of the boiler becomes the hottest, therefore the water circulation is upward at that point, then it travels toward the smoke-box end, down at the front end and continues along the bottom of the boiler to the rear end. Again the water raises, and this point deposits scale and mud that is too heavy to rise with the water. This deposit usually occurs in the vicinity of the blowoff pipe. The rear of the boiler shell should be lower than the front end; 1 in. for every 12 ft.

This discussion of fireboxes applies to small h.r.t. boilers up to 2,000 sq.ft. Here on the West Coast, most large water-tube boilers are fired with mill refuse on inclined grates; a few use flat grates. In either case, regardless of the size of the boiler, the principles described here are used in the successful installations.

Salem, Ore. H. R. RILEY

Another Mistake in the Water Column

ON PAGE 107 of February *Power* is a picture of a water column having at least sixteen mistakes listed on page 108. I agree to all of them. However, there is a mistake which is not listed and to me seems very important, that is the openings for gage cocks. In the A.S.M.E. Boiler Code, Par P-294, it requires that the gage cock openings in a water column be located within the range of the visible length of the water glass, therefore in this particular instance the opening for the lower gage cock should be raised up, the opening for the upper gage cock lowered, and the center gage cock opening placed midway between the upper and lower opening.

I believe the water column shown is of the old type as all new ones now on the market are in accordance with Par P-294 of the A.S.M.E. code in reference to gage cocks.

Albany, N. Y. S. A. BOWAN,
Boiler Inspector

Safety Valves for Air Compressors

RECENT numbers of *Power* have given a lot of attention to compressed-air explosions, but proper safety-valve protection for compressed-air systems is an important point which has been given little consideration. The safety valve or valves should have sufficient capacity to discharge all air that can be delivered by the compressor system without allowing more than 10% over maximum allowable working pressure to build up in any part of the system.

Safety-valve discharge capacity is rated in cubic feet of free air per minute. The first step in determining the proper size of safety valve to install is to determine the discharge capacity of the compressor in terms of c.f.m. of free air. This generally may be obtained directly from the nameplate of the machine if it can be ascertained that it is impossible to operate at above rated speed. Otherwise this capacity may be obtained by the following formula:

$$Q = 0.000455\ DLNCS$$

Q = c.f.m. of free air.
D = compressor cylinder bore in in.
L = stroke in in.
C = number of strokes per revolution (one for single-acting)
S = rotative speed of compressor, r.p.m.

The minimum size of a safety valve to use may be found by the formula adopted by the A.S.M.E. Code for unfired pressure vessels:

$D = Q \div (28PL)$

D = diameter in in. of inside edge of bearing surface between valve disk and seat
Q = discharge capacity in c.f.m. of free air.
P = absolute pressure at which safety valve opens
L = vertical lift of safety valve disk from seat representing minimum discharge capacity for satisfactory valve operation.

This formula is for 45-deg. bevel-seat safety valves. For flat-seat valves use a constant of 40 in the formula instead of 28.

As a typical installation, consider a single-stage compressor, belt driven by a squirrel-cage induction motor. The motor pulley is 6 in. in diam., and the compressor pulley is 36 in. Motor speed is 1,750 r.p.m. and compressor dimensions are: bore 12 in., stroke 10 in. The compressor is double-acting and single-stage. Rated discharge capacity is 150 lb. per sq.in. gage. What size safety valve should be installed?

The rotative speed of the compressor will be $(1{,}750 \times 6) \div 36 = 292$ r.p.m.

Solving for c.f.m. of free air compressor discharge:

$$Q = 0.000455 \times 12^2 \times 10 \times 1 \times 2 \times 292 = 378 \text{ cu.ft.}$$

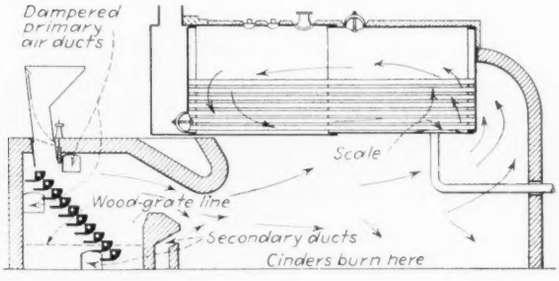
Assuming the safety valve has a minimum lift of 0.045 in., then the size of the safety valve is

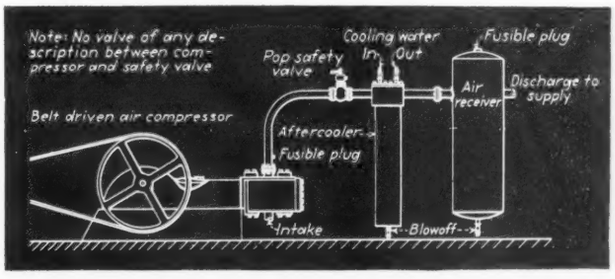
$$D = 382 \div [28 \times (150 + 14.7) \times 0.045] = 1.84 \text{ in.}$$

The next largest safety valve is 2 in. in diameter and will discharge the equivalent of 410 c.f.m. of free air, which is over the maximum possible discharge capacity of the compressor.

The location of the safety valve is important, and the diagram shows a satisfactory installation. If the safety valve is on the air receiver or discharge piping between the compressor and the receiver, there should be no shut-off valve between the safety valve and the compressor. If such a valve is in the piping, it might be accidentally closed and cause an excessive pressure on the compressor.

Cleveland, O. CHARLES A. ARMSTRONG





Combustion Arch Reduces Smoke

JUST read with interest "No More Smoke" by J. D. Relyea. He has progressed in the right direction in providing more combustion space, but using steam jets for smoke abatement is expensive and wasteful and should be used only as a last resort.

A sloping bridge wall with flat grates, I think, is of no benefit, rather otherwise, but I may be in error on this point. We have sloping grates here and slope the bridge wall from the fourth course to the top with good combustion and very little grate renewal.

A few years ago we installed overfeed stokers according to manufacturer's specifications. When we started this new equipment we made excessive smoke, and efficiency was extremely low.

We made various changes in height and shape of bridge wall and got nowhere. An observation of the fire from the cleanout door at the rear disclosed a lack of turbulence, the flame came over the wall, hugged the shell of boiler all the way back and gasses were stratified.

I discussed this with one of my superiors and obtained permission to build a combustion arch 3 ft. in back of bridge wall. I made this of plastic material. This was the answer to our problem. We not only reduced smoke to the vanishing point, but also increased efficiency to a very marked degree.

These arches are now incorporated in specifications on resetting contracts. I don't recommend this as a cure-all, but it is certainly worth consideration when smoke inspectors are on your neck.

Mechanicsville, N. Y. R. F. LEACH

How Wide a Gasket?

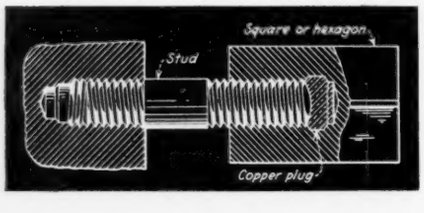
A COMMON error made when cutting gaskets is to make them the full diameter of the flange, and then punch holes in them for the bolts. The part of the gasket outside the inner side of the bolt circle will not assist in preventing leakage and may even cause leaks.

If the gasket is cut to fit just inside the inner bolt circle, the work of punching the bolt holes will be eliminated, and it will be much easier to put into place the circle of bolts centering the gasket. When a gasket is installed in this way, a tighter joint results and a much higher loading per unit area is obtained than when the gasket is the full width of the flange.

Omaha, Neb. EMIL J. NOVAK

Improved Stud Driver

THE stud driver in *Power* prompts me to describe a simple type I use. This design, illustrated, has a copper plug to protect the stud end. The copper does not damage the stud, and the driver can be removed easily. Square or hexagon stock may be used for making the driver. The inside end of the hole is bored a little larger than the threaded section, to hold the copper plug in place.



Shipley, England F. DOUGHLES

Tri-Sodium Treatment

WATER *which we are using for our boiler feed has the following analysis:*

Silica	*16.0*
Iron	*0.02*
Calcium	*135.0*
Magnesium	*42.0*
Sodium	*19.0*
Potassium	*1.8*
Carbonate	*0.0*
Bi-carbonate	*444.0*
Sulphate	*123.0*
Chlorides	*40.0*
Nitrates	*0.3*
Total dissolved solids	*610.0*
Total hardness	*510.0*
Total hardness also given as 28-30 grains	

How would you figure the soda-ash treatment and the tri-sodium treatment for water of the above analysis? Using this form of analysis I have been unable to follow through the article on water treatment as given in the December, 1932, number of "Power"—M.O.B.

The analysis can be stated as follows to include the "equivalents" per million:

	p.p.m.	Equiv. per million
Calcium, (Ca)	135	6.75
Magnesium, (Mg)	42	3.43
Sodium, (Na)	19	.82
Potassium, (k)	1.8	.04
Silica, (Si)	16	.53
Bicarbonate, (HCO_3)	444	7.25
Sulphate, (SO_4)	123	2.56
Chloride, (Cl)	40	1.14
Nitrates, (No_3)	0.3	.005
Hardness as $CaCO_3$	513	(30 grains per gallon)

The equivalent weight of a substance is the weight which occurs in compounds containing one atom of hydrogen. For example, one atom of calcium exists in the compound $Ca(HCO_3)_2$ containing two atoms of hydrogen. The atomic weight of calcium is 40, so the equivalent is 20. The water referred to here contains 135 p.p.m. calcium, so the "equivalent" weight is $135 \div 20 = 6.75$ p.p.m. The use of the equivalents simplifies some of the calculations for amounts of chemicals required for treatment.

The "equivalent" weight of soda-ash (Na_2CO_3, molecular weight 106) is 53.

The "equivalent" weight of anhydrous tri-sodium phosphate (Na_3PO_4, molecular weight 164) is 54.6.

The "equivalent" weight of mono-hydrated tri-sodium phosphate ($Na_3PO_4 \cdot H_2O$, molecular weight 182) is 60.6.

The amount of soda-ash used is that necessary to react with the non-carbonate hardness in the water. Total hardness in the water includes all the compounds of calcium and magnesium, whereas the carbonate hardness includes only the bicarbonates of calcium and magnesium. Therefore, if the equivalent weights of calcium and magnesium be added and the equivalent weight of the bicarbonate radical be deducted from the total, the remainder is the equivalent weight of the non-carbonate hardness. If the equivalent per million of the non-carbonate hardness be multiplied by the equivalent weight of soda-ash, the result will be the parts per million of soda-ash required for the reaction. This quantity can be converted into terms of pounds per thousand gallons of water by dividing it by 120. The net result can be expressed by a formula as follows:

$$\text{Lb. of soda-ash per 1,000 gal. of water} = \frac{(\text{Ca. equiv.} + \text{Mg. equiv.} - \text{HCO}_3 \text{ equiv.}) \times \text{soda-ash equiv.}}{120}$$

$$= \frac{(6.75 + 3.43 - 7.25) \times 53}{120}$$

$$= 1.3 \text{ lb.}$$

The theoretically required amount of anhydrous tri-sodium phosphate required to react with the calcium in the water can be calculated from the following formula:

$$\text{Lb. of anhydrous tri-sodium phosphate per 1,000 gal. of water} = \frac{\text{Ca equiv.} \times \text{anhydrous tri-sodium phosphate equiv.}}{120}$$

$$= \frac{6.75 \times 54.5}{120}$$

$$= 3.1 \text{ lb.}$$

$$\text{Lb. of mono-hydrated tri-sodium phosphate required per 1,000 gal. of water to react with the calcium.} = \frac{\text{Calcium equiv.} \times \text{mono-hydrated tri-sodium phosphate equiv.}}{120}$$

$$= \frac{6.75 \times 60.5}{120}$$

$$= 3.4 \text{ lb.}$$

The foregoing will serve as a guide to the amounts of chemicals required. In actual practice, a slight excess over the theoretical is required in order to maintain in the boilers a certain concentration of CO_3 or PO_4 as determined by frequent periodic tests of the boiler water.

New York, N. Y. W. J. RYAN
Water Service Laboratories

How to Make Exciter Maintain Voltage

I HAVE read with interest the answer to the question "Exciter Cannot Maintain Voltage" and wish to offer the following suggestions: If the series and shunt-field coils are not in opposition, the field poles may be operating near saturation. In the latter case the series field winding would have very little effect. Steam pressure may be low or the buckets and nozzle may be eroded, if a steam turbine is the prime mover, causing the speed to be low. Also the governor may not respond as it should.

I have increased the speed of turbine- and engine-driven generators to increase their voltage above normal. Then by bringing the voltage to normal with the field rheostat, the field poles operate farther down on the saturation curves, making the series-field ampere-turns more effective and improving generator regulation.

I would advise H.M.F. to check prime-mover speed and note the governor action. The no-load generator voltage should be between 140 and 160 when the field rheostat is out of circuit. The difference between this and normal voltage is absorbed by the field rheostat.

Secaucus, N. J. OTTO SCHOLL

READERS' PROBLEMS

QUESTIONS for Our Readers

Ammonia Condenser Trouble

Question 1

THE *ammonia condenser of our 15-ton direct-expansion refrigeration system has four double-pipe coils 10 pipes high. Recently ammonia was found in the cooling water leaving the condenser. Litmus paper tests showed the ammonia-contaminated water to be coming from only two of the coils. Upon closer examination one of the returns was found to be hot when the compressor was shut down and condenser cooling water was not circulating. The section was immediately shut off. After I had drawn up on all bolts at the end of the coils I opened the drain valve to the receiver. Pipe hammer developed at once and this time another return, lower down, became hot and a boiling sound could be heard. The other coil stopped leaking as soon as the bolts at the end of the coils were tightened and did not heat at any time. Will POWER readers please tell me what action caused the hammering and what caused the returns to heat?*—O.J.F.

Boiler Tubes Leak

Question 2

WHAT *would cause the tubes of our horizontal-return-tubular boiler to leak at the rear ends? This condition is prevalent in the upper rows. We have rolled and re-rolled these tubes and even put in new ones, but trouble from leaks still persists.*—S.H.M.

Suitable answers from readers will be paid for if space is available for publication.

OIL IN BOILERS

ANSWERS to March Question 1

The Question

WE HAVE *been troubled from time to time with oil in our boilers, and recently on opening the boilers for cleaning and inspection, we found soft scale deposits. What simple and practical test can we apply to these deposits to determine whether there is any oil in them?*—H.M.S.

Dissolve Oil in Chloroform

USUAL determinations of oil in boiler scale involve drying the powdered scale to remove moisture and extraction of the oil from a measured amount of the dried material. Ether is a common extraction solvent. Analytical weighing and careful filtration required prevent adoption of the process in off-hand boiler-room tests.

A method for determining oil carried in water might be applied to boiler scale for roughly quantitative analyses. First, pulverize or grind a sample of boiler scale, disregarding preliminary drying. Fine grinding is essential if accuracy of results is desired. Stir the scale specimen into a quantity of chloroform, anesthetic grade. Pour off and save the oil-bearing chloroform. Treat the scale with additional portions of chloroform, saving and combining applications of the liquid as they are decanted or filtered from the specimen. Fresh portions of the solvent are applied to the scale until the desired completeness of oil extraction is evident. The combined extracts, if cloudy, should be filtered through filter paper. Water should be poured off. Oil contained in the chloroform can be recovered by evaporation of the solvent in a container heated over water boiled in an open vessel. A conventional double boiler arrangement is often satisfactory, if ignition of the chloroform vapor can be avoided.

Corvallis, Oregon R. E. SUMMERS

Use Gasoline

IF H.M.S. does not have a laboratory, and I assume he hasn't, take a fairly big sample, a handful or two, of the scale and place it in a clean bottle. Add about a quart of uncolored gasoline, shake vigorously and let settle, about three times at 1-hr. intervals. Then allow to settle until clear, say until the next day.

Almost every possible grease or oil likely to be in the boiler is soluble in gasoline. Most oils have color and will color the gasoline, thus giving a positive indication. But if the sample gives a color to mask the oil color, this preliminary test may fail.

With care you can get quantitative results that are correct within at least 10% and very likely 1%. Filter the liquid, but decant carefully to save time. Place the liquid in a clean glass or white glazed basin, cover with cloth to keep out dust and put where it is warm, but not likely to catch fire, so the gasoline will evaporate. As oil or grease in the sample is only dissolved by the gasoline, it will be left behind in the basin as the gasoline evaporates.

Remove the oil with a previously weighed blotter and the gain in weight is the weight of oil in the sample.

I can hear you say, "I can't weigh in such small amounts," but you can weigh to 0.1 or 0.025 lb. if you have a platform scale in good condition and accurate to 1 lb. in 400.

The balancing arm of a common platform scale is graduated in pounds and the lever system has a ratio of 100 to 1, that is, a 1-lb. weight balances 100 lb. on the platform. So get a bucket and weigh out exactly 100 lb. of sand, brick or anything convenient and remove from the platform. Then remove the hook on the end of the balance arm and replace with a scoop weighted to balance the empty platform exactly.

Now suppose with the clean blotting paper placed on the scoop and the 100-lb. bucket of sand on the platform the beam is balanced with the slider at 97 instead of at 100 as originally, then by difference the blotter weighs 0.03 lb. Now if we had exactly ½ lb. of scale, and with the oily blotter the scale balances at 90, we have 0.07 lb. of oil in 0.5 lb. of scale, or 14%.

The above method can be used with fair accuracy to obtain total solids in feedwater and is a handy kink in the power plant.

Detroit, Mich. F. G. DAWSON

Vaporize Oil By Heating

PLACE several samples of scale in an erlenmeyer flask and dissolve in hydrochloric acid. Add 15-25 cc. of C.P. ether and shake the scale, acid and ether thoroughly. Decant liquids into a separating funnel and allow the water and ether to separate. Drain off water and then pour the ether into a casserole. Evaporate ether at low temperature. If any oil is present it will show as a greasy deposit in the bottom of the casserole.

If there is very much oil entering the boiler it will cause a deposit or discoloration of the boiler scale at the water line. By taking pieces of this scale and heating in a crucible to a dull-red heat the oil will be volatilized, changing the appearance of the scale. The volatilized oil will probably ignite as it is driven off.

Ensley, Ala. J. R. HUNT

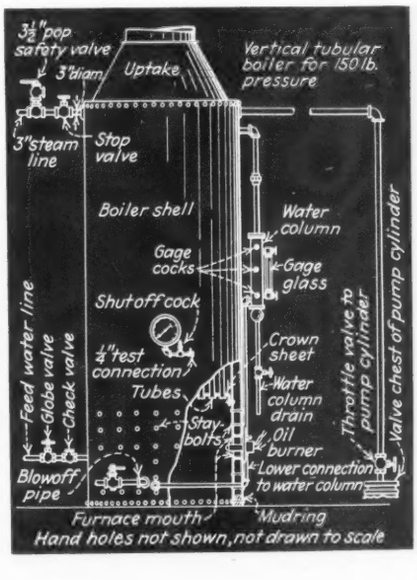
Remove Oil From Feedwater

CHARACTERISTICS of boiler scale vary with the nature of the substance which forms the scale. Carbonates of lime and magnesia

WHAT'S WRONG WITH THIS PICTURE?—IV

COMMON VERTICAL TUBULAR BOILER ERRORS

THERE are at least 16 mistakes shown in this drawing. Make a list of those you can recognize, then check against the list on page 281



usually produce a soft porous scale, as does sulphate of magnesia alone. These scales are usually easily penetrable by water. With high concentrations, a certain amount of this soft scale will usually be left in the drums after draining a boiler.

Oil in quantity enough to cause trouble in boiler feedwater would undoubtedly show up as a greasy film in the gage glass of the feedwater heater. However, under the right conditions it is possible to have a deposit of scale with oil in it. If carbonate of magnesia precipitates as a light, flocculent, scum-forming substance and comes in contact while in this form with a considerable quantity of oil, the two impurities may combine to produce a distinctive spongy scale, which is exceptionally troublesome due to its extremely high resistance to heat transfer. This trouble is usually limited to low-grade compound lubricating oils which may also cause foaming.

Mineral-oil contamination usually adheres to the heating surface directly, thus insulating it and often causing blistering or bagging. However, under certain conditions it may act as a binder and cause sludge deposits to accumulate.

Waynesboro, Pa. J. M. MYERS

Dissolve Scale With Hydrochloric Acid

THE following methods can be used to identify oil in boiler scale. They should be tried in the order listed, depending upon the kind of scale.

1. Carbonate scale can be decomposed by hydrochloric (muriatic) acid, and the oil will separate as a scum which is readily identified.

2. Other than carbonate scale should be digested with caustic soda and the oil will separate or saponify and become soapy.

3. Any type scale can be crushed, dissolved in strong acid, evaporated to dryness, and the oil extracted with ethyl ether. The ether is then evaporated off, after filtration, and the oil is the residue.

Chicago, Ill. T. E. MATTOX

Test Boiler Water

WHILE I know of no practical test that can be applied to scale to indicate the presence or absence of oil, it may be safely said that the scale being relatively soft does not necessarily indicate oil is present. Further, a test of the condensate reutrned to the boiler is of greater value, because it is known that in nearly every case oil gets into the boiler through the return of oil-laden condensate, and because such a test can be made periodically as a matter of insurance, with relatively little trouble.

The test is based on the affinity of oil for ether, and is made with a separating funnel. Mix thoroughly in the funnel, by shaking ten parts of cooled condensate with one part of ether, and after thorough shaking allow the funnel to remain at rest for about 15 min. in a vertical position. At the end of this time open the cock at the bottom and draw the water off. The ether together with the oil floats on top and remains.

If the water is carefully measured at both ends of the process, just the right quantity can be drawn off, and the oil and ether will remain. The oil and ether can now be placed in a cereal bowl or similar white dish, and heated above an ordinary double-boiler. This heating will quickly evaporate and drive off the ether, and such oil as may have been present in the water sample will be left alone in the bottom of the white dish, where it can be clearly seen. Separating funnels may be obtained from most chemical firms that manufacture laboratory ware.

Peoria, Ill. JOHN E. HYLER

Translucent Spot on Unglazed Paper

THE simplest test I can think of would be to remove some of this soft scale, if possible clear to the metal, with a knife or scraper. Place the scale removed on a piece of unglazed or porous paper—drawing paper or even school tablet paper will answer. Apply heat, as in an oven, from a small light bulb or a radiator. After a short period of time, if oil is present, a translucent spot will appear on the paper. The more oil present, the quicker this spot will appear, and the larger it will be.

A more elaborate test is, to place removed scale in a small flask and cover with ether, shake and let settle. Pour off the clear liquid into another small flask and add about the same amount of half-strength solution of alcoholic potash. If time permits, allow to stand cold overnight. Presence of oil will be indicated by saponification.

If time is short and results are wanted sooner, a quicker, but not quite as safe a method, can be used. After adding the alcoholic potash solution, heat on a water bath with a 1-in. funnel inserted in the mouth of the flask to hold back and condense fumes. After a short period of heating, allow it to cool. If oil is present, saponification will be shown by the homogeneity of the solution.

Canton, Ohio HARRY T. MCCARTY

Use Ether As Solvent

ANY oil present in the scale deposit may be detected by ether extraction, with subsequent evaporation of the ether from the extract, leaving the extracted oil as a residue in the container.

The deposit should be dried at a temperature of about 100 deg. C. or lower. After cooling it should be transferred to a stoppered bottle, to which is added a quantity of ether, about two or more times the volume of the deposit. The ether may be obtained from a drug store. It is inflammable and should be used about an open flame with caution. The contents of the bottle are shaken at intervals for 1 hr. or longer. If equipment is available, the liquor is filtered from the residue through filter paper in a funnel. However, if given sufficient time, the residue will settle to leave a clear liquor, the bulk of which can be poured off or siphoned from the residue. The separated liquor is evaporated by warming in an open vessel. After the evaporation of the ether oil present in the original deposit will be left in the vessel as a characteristic oily deposit.

Nashville, Tenn. R. T. COCHRAN

GENERATORS WON'T SYNCHRONIZE

ANSWERS to March Question 2

The Question

IN OUR *plant we have three 2,200-volt, 60-cycle generators which we will call A, B & C. A has a 187-kva. rating. B & C are 312-kva. capacity each and supposed to be duplicates. All are driven by compound steam engines. Operation of all three in parallel is satisfactory, also operation of A and B, but A & C cannot be synchronized except by cutting in all three and then taking off generator B. After B is taken off the operation of A & C is satisfactory. B & C go in together nicely and operate satisfactorily together. Any attempt to synchronize A & C results in a momentary voltage drop and a violent swing of the voltmeter pointers. The over-current coils on the generator switches operate, disconnecting the machines even when set at nearly double nameplate rating. We use a synchroscope and voltage regulator. Why can't we synchronize A & C?*—C.McD.

Fault Is With the Engine

IT APPEARS the trouble is entirely up to the engine. The only way to control the load distribution between two alternators in parallel is to adjust the governor as if to vary the speed of the prime mover. Any attempt to raise the voltage on one machine by increasing its excitation will simply set up a circulating wattless current between the two machines. This current will weaken the field in the overexcited machine, and strengthen it in the other, resulting in a slight increase in the line voltage, but practically no change in the load distribution.

Woodbury, N. J. R. W. CATER

Suggests Improved Synchronizing Technic

THE question by C. McD. is difficult to answer without having a chance to do some experimenting on the machines. In all probability the fault is with the governor on Machine *C*. When it is synchronized with Machine *A* the governor on *C* responds so slowly that *A* is overloaded and its circuit-breaker trips. Synchronizing should be done with the pointer on the synchroscope turning slowly in the fast direction. When to close the switch is a matter of experiment. Normally, the pilot switch should be closed when the point is approaching the mark and is about 0.5 to 0.25 in. away from it. The machine then drops into step and begins to pick up some load.

If the governor is sluggish on unit *C*, synchronizing it when running slightly faster than is the practice with the other machines should help to bring it into step and keep it there. The faster the machine is running,

compared to the machines on the line, when the switch is closed, the greater tendency it has to pick up load. I would suggest that McD. do a little experimenting with *C* and try synchronizing this machine with it tending to run faster than the other machine, when the switch is closed. In all cases close the switch when the machine is coming into synchronism, that is, when the needle is approaching the mark. Never close the switch after the needle passes the mark. The machine is then going out of step, and to pull it back requires a heavy synchronizing current. Even though the governor may be sluggish I believe that a synchronizing technic can be developed that will put the machines together without tripping the breakers.

Cleveland, O. C. A. ARMSTRONG

Governor on Machine C Requires Adjustment

THE probable cause of C. McD's trouble is a sluggish governor on the unit driving Alternator *C*. The synchroscope indicates synchronism, and the main switch of *C* is closed, connecting it to the bus. Unit *C* drops slightly in speed. *A* then supplies a synchronizing current to *C* tending to operate that unit as a synchronous motor and bring it back into step. The governor on *C* does not act quickly enough for the engine to pick up the load imposed on it and as a result a synchronizing current flows between the generators that exceeds the capacity of unit *A* and the circuit breakers trip. In the worst case, unit *C* may slip a pole, causing a short circuit between the two machines that trips the breakers on both alternators.

Synchronizing *C* with *B* would produce the same effect as synchronizing *C* with *A*. The circuit breakers would not trip, however, because *B* has sufficient capacity to supply the required synchronizing current safely and hold *C* in step until the governor acts. *A* can now be synchronized and connected to the bus. Any lag of the governor on *C* would be of no moment because there being two units to hold *C* in step.

New York, N. Y. MILTON N. KRAUS

Raise Voltage of Incoming Unit

ALTERNATORS *A* and *C* can very likely be made to synchronize by raising the voltage of the incoming generator above normal—possibly as much as 10%. In running some tests on a small generator we once had this experience, and we believed that its wave form did not conform closely enough to that of the power supply. If this conclusion applies in the installation described it will never be possible to obtain "smooth" synchronizing of the two machines, but I believe the method suggested will work.

Albuquerque, N. M. RALPH J. RAINEY

Synchroscope May Be Connected Wrongly

WHILE the question does not state whether the synchroscope is connected between machines or incoming machine and the bus, if the former is the case the following solution will apply:

Assuming the synchronizing potential transformer on Machine A is connected to Phases A and B while on Machine B, it is connected between Phases B and C with potential reversed, this would result in a displacement of thirty degrees between the machines when the pointer shows them in phase, but the machine would probably pull in step.

Also assume the potential transformer on Machine C is connected between phases A and C with the potential the same as on Machine A, this would produce a thirty degree displacement between B and C with the action the same as before.

However, if an attempt is made to synchronize between A and C, the displacement would be sixty degrees which would certainly be too much for the machine to pull in step.

Altoona, Pa. A. R. MARKLAND

WHAT'S WRONG WITH THIS PICTURE?—IV

COMMON VERTICAL TUBULAR BOILER ERRORS—See Page 279

The more common errors in connecting appliances and piping to a vertical tubular boiler are discussed in this article.

1. *Safety Valve Not Flanged.* Quoting from Paragraph P-286, A.S.M.E. Power Boiler Code, "a safety valve over 3 in. in size used for pressures greater than 15 lb. per sq.in., shall have a flanged inlet connection."

2. *Safety Valve Discharges towards Boiler Top.* All safety-valve discharges should face or be piped clear of any passageway, runway, or point necessary for a man to stand when operating valves, etc. Valves should be drained.

3. *Stop Valve between Safety Valve and Boiler.* Safety valves should be attached directly to the boiler with no intervening valves of any description. Many states require the safety valve or valves to be connected to the boiler by an independent connection in all new installations.

4. *Safety Valve Connecting Pipe Reduced.* The connecting pipe between the safety valve and the boiler should be equal in diameter to the safety valve. Should the pipe be reduced in size, a friction drop would result when the safety valve opened. This might equal the blowdown setting, and the valve would then close. Cessation of flow would allow the valve to pop again. This action would continue its cyclic reversals practically instantaneously until the pressure had dropped to below the blowback setting. The result would be a destructive hammering action.

5. *Water Column Too Low.* The lowest visible point on the gage glass should be at least 2 in. higher than the lowest safe water level. Lowest safe water level for this type of boiler is one-third the height of the boiler tubes above the lower tube sheet.

6. *No Drain for Gage-Glass Connection.* Failure to provide a blowoff cock or valve for this connection may result in an accumulation of sediment sufficient to block the connection. Water would then show in the glass even though the water level in the boiler might be dangerously low.

7. *Feedwater Valve in Wrong Position.* There should be a stop valve between the check valve and the boiler. The stop valve outside of the check valve is unnecessary unless more than one boiler is supplied by the same feed water system.

8. *Feedwater Discharging in Wrong Place.* An extract from P-314, A.S.M.E. Power Boiler Code reads, "in vertical tubular boilers having tubes 4 ft. or less in length, feedwater shall be introduced at a point not less than one-fourth the length of the tube above the lower tube sheet. For tubes more than 4 ft. in length, feedwater shall be introduced at a point not less than 12 in. above the crown sheet."

Discharging feedwater against the hot furnace sheet causes serious contractive stresses which may result in cracking of the plate. It also accelerates corrosion in the waterleg parts.

9. *Blowoff Connection Too High.* Blowoff piping should be connected to a boiler at the lowest practicable point. In the vertical tubular boiler, this would be directly above the mud-ring or ogee flange. Otherwise sediment accumulations could not be blown or drained out.

10. *Lower Connection To Water Column Wrong.* The lower connection from the water column to the boiler should be connected not less than 6 in. below the lowest allowable water level and as near thereto as possible. In no case should it be less than 18 in. above the mud-ring or ogee flange.

11. *Gage Cocks are Too Far Apart.* The gage cocks should be located within the visible range of the gage glass. They are used to check water level during times of gage-glass replacements and if not within the specified limits it will be impossible to control water level correctly.

12. *No Stop Valve on Steam Outlet.* A stop valve is required on every steam outlet from a boiler (except safety valve or superheater connections), and the stop valve should be as close to the boiler as practicable.

13. *No Drain on Steam Line to Pump.* A valved drain should be provided in the steam line to the pump. Drain should be just above the throttle valve and as close to it as possible so that the line may be blown free of condensate before starting the pump.

14. *Mud Ring Unprotected.* When grates of a vertical fire-tube boiler are removed to burn fuel in suspension, it is necessary to protect the lower part of the furnace sheet at the mud ring, and the rivet heads from overheating. Brickwork should be built up around the circumference of the furnace sheet for at least 4 in. above this riveted seam.

15. *One Blowoff Valve.* Two slow-opening blowoff valves or one slow-opening blowoff valve and a cock are required when boiler pressure exceeds 100 lb.

16. *Steam Gage Connected to Water Space.* The pressure gage should be connected to the steam space of the boiler. Connecting it below the water line would increase the possibility of the gage piping becoming obstructed with sediment or solids in the water. Likewise it does not indicate the steam pressure correctly.

New York, N. Y. HARRY M. SPRING

MIDWEST CONFERENCE

A GREAT variety of power problems was covered by the program of the Sixth Midwest Power Engineering Conference at the Palmer House, Chicago, April 20-23. In 12 sessions and 32 papers, leading engineers presented practical information on: Power Economics, Power-plant Buildings, Electrical Equipment, Diesel Power, Refrigeration, Coal Classification, Power Piping and Welding, Power-plant Technics, Fuels and Furnaces, Power Transmission Machinery, Fuel Economy and Controls.

Simultaneously with the conference, 110 exhibitors displayed power and related equipment at the 7th Midwest Engineering & Power Exposition in the International Amphitheatre.

Dean A. A. Potter of Purdue, president of the American Engineering Council, presided at the session on Power Economics, where C. F. Hirschfeld of Detroit Edison summarized "Trends in Research" and Wm. A. Hanley of Eli Lilly & Co. (Indianapolis) advised utilities and industrials to cooperate wholeheartedly in the exchange of power.

Dr. Hirschfeld stressed the importance of more fundamental economic and social thinking in power matters, summed up today's power research advances and pointed to possible paths of future progress. Following is a digest of some of his comments:

Work of research engineers promises extension of our present commercial steam temperature limit of approximately 950 deg. F. The trend is to eliminate reheating and use the highest steam pressure which can be used at the existing safe temperature limit without producing excessively wet steam at the turbine exhaust. Further pressure advance may become possible through new and inexpensive methods of protecting the low-pressure blades.

Radical Boilers

American interest is growing in the Loeffler, Velox, Benson and other radical European boiler designs. Forced circulation units may figure prominently in American boilers of the future. Acceptance of welding has tended to liberalize boiler construction in many respects. We may therefore expect the future to make possible a superabundance of new boiler forms. Research has made such a mechanic's art as tube rolling a scientifically controllable process.

Large stoker practice tends toward combined water cooling and zoned air control, greatly widening the range of available fuels. We seem to be approaching the time when remote control of steam-generating equipment may be a possibility, but many intricate practical problems await solution.

In some plants solid smoke and dust from stacks have been eliminated, but at great cost. The power world awaits the genius who will go further, salvage the sulphur, and return it as a salable byproduct.

Turbine units up to 50,000 kw. are now built for 3,600 r.p.m. Some of these use aluminum conductors on the generator rotor. Turning engines, now widely used to keep shutdown turbine rotors uniformly warm, and thus avoid warpage, permit smaller design clearances with safety, hence better performance, greater availability, or both.

Condenser design may soon profit by the application of aerodynamic theory. The problem of condenser-tube failures is now being attacked in a nation-wide research of great promise.

In the field of electrical equipment, hydrogen cooling has been applied to generators. Insulating oils are the subject of unprecedented study. Electrostatic generators of large capacity are well advanced in the experimental stage, and electrostatic motors have been operated satisfactorily. A semi-commercial system of d.c. transmission has been developed. The time is ripe for new developments to cut the still very-high cost of long-distance electrical transmission.

Discounting excessive claims, the diesel has made phenomenal progress in recent years. Diesel success, in turn, has encouraged the development of small, self-contained and practically automatic high-pressure, high-temperature steam plants, but much still remains to be done along this line. In the smaller sizes, the reciprocating steam engine in a form similar to the modern automobile engine may have applications. A plant of this general type is already on trial in the rail field and may prove competitive with the diesel in that field and in others.

Power Exchanges

Mr. Hanley urged utility executives to adopt a more sympathetic attitude toward the exchange of power with industrials, particularly that they consider the sale of steam to suitably situated process industrials under an arrangement whereby excess power generated in the customer's plant from that steam will be returned to the utility. Wide exchange of this sort, he said, would eliminate many stacks and inefficient small plants, as well as improve the smoke situation. He felt that such distribution of steam would ordinarily be practicable up to a distance of 2 mi. from the central station.

Mr. Hanley said that Eli Lilly uses 1,250,000 lb. steam daily and is not required to return condensate, so has that amount of distilled hot water available for process work, which is very helpful. The electrical peak is 4,000 kw.

At the conclusion of the session, plans for the coming World Power Conference in Washington in September were outlined by J. D. Wolfsohn, exec. secretary.

In a session on diesel power, a paper by G. E. Spain of Caterpillar Tractor discussed heavy-duty portable diesel engines for construction and contracting. Special requirements are rigidity, moderate weight, ability to run properly when tilted up to 30 deg., fool-proof construction and maintenance, moderate cost.

Max Rotter, vice-president in charge of engineering for Busch Sulzer, showed many cross-sections of diesels of various makes. His paper dealt entirely with large diesels. He reported a statistical study of 180 large engines now under construction, aggregating 730,000 hp. Of these, 48 are 4-cycle, single-acting; 77 are 2-cycle, single acting (including 15 of the opposed-piston type) and 55 are 2-cycle, double-acting. There are no 4-cycle double-acting machines. All have mechanical fuel injection.

Mr. Rotter said that all large diesels built to date are vertical units. A separate pump for each combustion space is almost universal, the pump measuring and timing injection. Fuel valves and nozzles are becoming conventionalized. All large diesels are fitted with removable cast-iron liners and all pistons are cooled by water or oil. Fuel consumption averages one gallon per 13½ to 14 kw.-hr.

T. M. Robie of Fairbanks Morse listed the following requirements of diesel fuels for modern, high-speed, solid-injection engines: Boiling point: distill at least 95% over at 700 deg. F.; Conradson Test: limit 2%; Viscosity: 35 to 75 sec. Saybolt Univ. at 100 deg. F.; Ash: 0.5%; Bottom sediment and water: not over 1%; Sulphur: not more than 1.5%; Gravity, color, flash point: not important.

Controversy between those for and against government power policies has not always been on strictly logical grounds, but every speaker in the Wednesday afternoon session on "Engineering Economics in the National Power Picture" based his arguments on engineering and economics.

Gordon Fox, vice-president of Freyn Engineering Co., representing the utility side, posed the questions.

The case for the government, specifically the Tennessee Valley Authority, was presented in a paper sent in by A. E. Morgan, Chairman of T.V.A.. The T.V.A. said Dr. Morgan, was started to build up the prosperity of the Tennessee Valley by coordinated activities involving flood control, erosion prevention, agricultural rehabilitation, industrial development and (incidentally) power. The power aspects have been overemphasized in public discussions. Dr. Morgan said that proper allocation of total construction costs to these objects did not leave an unduly high *power* investment.

Private Development

Frank F. Fowle, president of the Western Society of Engineers, presented the case for development of the nation's power supply under private enterprise. Following are some of his conclusions:

Assuming $85 per kw. for a good steam plant and $250 per firm kw. of hydro capacity, a mine-mouth steam plant on $1.60 coal can produce a kw. for about 4 mills, while the hydro plant will require 6.3 mills.

In general a steam plant near the point of consumption is more economic than either a mine-mouth steam plant or a hydro plant distant from the load, because it is more

Explores Power from Many Angles

costly to transport electricity than the coal from which it could be produced. Here is the comparison:

	Transmission cost per kw.-hr. Electricity as such	Coal to produce one kw.-hr.
50 miles	1.65 mills	0.64 mills
100 miles	1.92	0.74
200 miles	2.42	0.94

In general coal can be hauled from 5 to 10 times as far for the same transmission cost.

In discussion, several speakers insisted that hydro power is very frequently economic, particularly in combination with steam, since plants with storage can carry the system peaks.

Frank R. Innes, western editor of *Electrical World,* said that all discussions of government power policy must be predicated on the assumption that individualism will prevail against collectivism. He attacked the validity of figuring low interest rates on government projects, saying that these are artificial and temporary. In particular he said that a 40- or 50-yr. amortization assumes the impossible, namely no marked advances in engineering in the next half-century.

Mr. Paul Battey, of Battey & Kipp, redirected the utilities' own argument of high transmission costs to justify a greater development of the individual factory and building power plant.

Geo. H. Hamilton, cons. engineer, said that he had closely studied the TVA work and found it efficiently conducted by engineers of broad experience. The Tennessee, he said, is particularly suited, by the nature of the river, and the activities, nature and distribution of the population, to a development of this sort.

At a largely attended dinner and dance on Wednesday evening Silas H. Strawn, past-president of the U. S. Chamber of Commerce, eloquently urged a return in America to government along our traditional lines.

In the session on Power Plant Technics (A. D. Bailey, chairman) F. H. Rosencrants, vice-president, Combustion Engineering Co., illustrated the trend of boiler design for high pressures and temperatures with discussion of features of units recently ordered—notably the 500,000-lb.-per-hr., 1,400-lb. pressure, 900-deg. F unit for N. Y. Edison (Waterside); the 450,000-lb.-per-hr., 925-lb. pressure, 835-deg. unit for Richmond, Va., and the 1,000,000-lb.-per-hr., 1,425-lb. pressure, 910-deg. unit for Logan, West Va.

Only a few incidental comments may be summarized: The superheater has evolved into a dominant factor in boiler design; frequently it has more surface, and absorbs more heat than the boiler itself. Control of superheat by some form of bypass and damper arrangement has become the accepted standard. Steam washers bid fair to become standard equipment, particularly in high-pressure installations.

An elaborate technical discussion of water conditioning for high-pressure steam generation was presented by Dr. R. E. Hall, director of Hall Laboratories, Inc. Here again only a few incidental comments are possible in the available space: Primary requirements for preventing corrosion are thorough deaeration and carefully controlled caustic alkalinity. Dissolved oxygen must be completely removed and mechanical deaeration should preferably be followed by chemical (e.g. by sodium sulphite). Continuous blowdown, proper baffling, proper water treatment and steam washers will lessen the difficulties of carryover.

Following Dr. Hall, J. M. Lenone of Wilson & Co., Chicago, showed how the installation of a 395-lb., 550-deg. "top" in his packing plant several years ago is now saving $163,000 yearly. Investment was $700,000.

In the Ssession on "Fuel Economy and Controls," A. F. Spitzglass and G. K. O'Connor, Republic Flow Meters Co., brought out the following points:

Control equipment must be able to move as fast as the boiler and auxiliaries over the whole range of load. Generally these fluctuations are more violent in the industrial plant. With stokers, control of steam pressure starts with air flow, firing rate being adjusted to this. With liquid gas or pulverized fuel, control starts with the fuel. Airflow may be controlled through either the forced or induced draft, the other then being used to balance the furnace draft. The Ward-Leonard System of drive is particularly useful in the parallel operation of pulverized-coal feeders.

Frank W. Clark, of Stone & Webster, gave a new slant on superposed plants, saying that they should not be accepted without question as a panacea for the modernization of old plants. Their greatest field, he felt, is in modernizing very old and inefficient plants carrying very low pressures and superheats. With these it is often possible to add 50% to capacity and 40% to efficiency. Efficiency gain comes from elimination of obsolete steam-generating equipment, as well as from the higher pressure. Mr. Clark indicated the "tops" are sometimes particularly adaptable to old industrial plants.

Space is lacking to brief other excellent papers presented at the Conference, subjects and authors as follows: Power-plant design, P. E. Stevens; Air Conditioning, Messrs. Zieber and Nicoll; Refrigerants, H. E. Edwards; Use Value of Coal, C. C. Wilcox and John Nash; Coal Sizing, Joseph Harrington; Coal Resources of Middle West, H. L. Olin; Values for High Pressure, H. H. MacMillan; Piping, J. Roy Tanner; Group Drives, W. R. Clendenning; Load Acceleration and Release, Wm. Stanier; Direct Motor Drives, F. E. Butterfield.

Mention has already been made of the 7th Midwest Engineering & Power Exposition, held simultaneously with the Midwest Power Engineering Conference, but at the International Ampitheatre (stock-yards) several miles away. Among the 110 exhibits were many of interest. Perhaps the most elaborate booth was that of Union Carbide (Linde Air Products and Haynes Stellite) which displayed welding equipment and Stellited valves, and staged welding demonstrations.

Richardson Scale Co. showed, for the first time, their 50-lb. automatic coal scale, capacity 3 tons per hour. New feature, aside from small size, is this: When scale is full it trips a mercoid switch which operates internal brake in ¼-hp. drive motor.

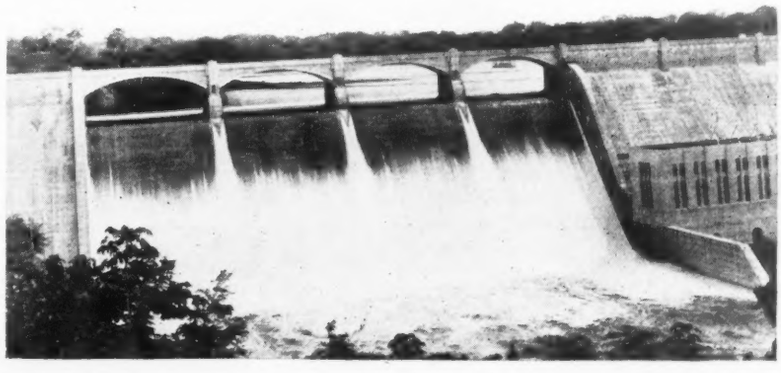
Askania Regulator Co. showed a new compact control unit, combining motor, pump, regulator and tank in a single small block.

Schutte Koerting announced a new flow control embodying vacuum-tube valves connected to the bridge element of their present electrical indicating "Rotameter." The tubes start a motor in the proper direction to adjust flow. Rate of adjustment is proportional to deviation.

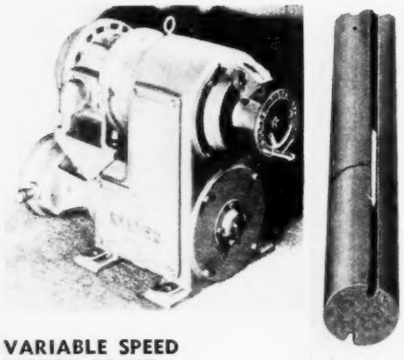
Faville-Levally Corp. used a model, fed with a mixture of sand and small coal, to demonstrate the even "fanning" action of their "stock" conical coal feeder for stokers.

POWER FOR PANAMA CANAL

Madden Dam and power house, built on the Madden River in the Panama-Canal Zone to provide more water and power for operating the Canal. The Dam is of the concrete gravity type 950 ft. long at its crest and 220 ft. maximum height. Provisions are made in the power house for three 11,200-hp. units, two of which have been installed and went into operation last year. The turbines operate under a head that ranges from 145 to 75 ft. at a speed of 214.2 r.p.m.



WHAT'S NEW IN PLANT EQUIPMENT



VARIABLE SPEED MOTOR DRIVE

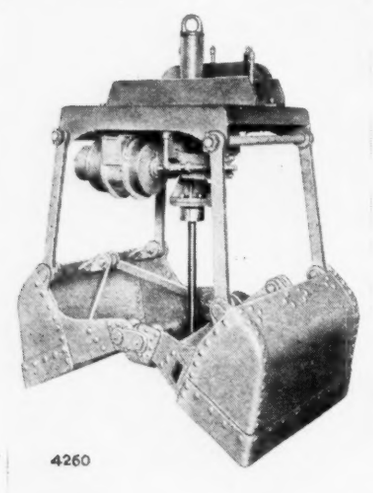
VARIABLE-SPEED drive combines in self-contained inclosure, any standard make of constant-speed motor, variable-speed control mechanism, and (where required) speed-reduction gears. Dial indicator registers speeds on scale calibrated from 1 to 6, as handwheel is turned. V-belt runs between two set of cone-faced disks adjustable in diameter and mounted on parallel shafts. One shaft receives power at constant speed from motor, while other shaft transmits power at adjustable speeds to any driven machine. Variable-speed shaft may extend on either side. Horizontal vertical drives in four sizes from $\frac{1}{4}$ to $7\frac{1}{2}$ hp. for speed ratios from 2 to 1 through 6 to 1. With helical gear reduction units ratios up to 189 to 1 are available. Output speeds from 1.35 r.p.m. to 3,480 r.p.m.

Reeves Pulley Co., Columbus, Ind.

ELECTRIC HYDRAULIC CLAMSHELL BUCKET

MOTOR-DRIVEN fluid pump controls hydraulic ram on bucket which can be hooked to crane, electric hoist or ordinary derrick. Opening and closing accomplished by electric motor controlled from operator's cab. No closing line or winding drum required. For power and industrial plants in digging and rehandling coal, ashes, ore, coke, slag and similar materials.

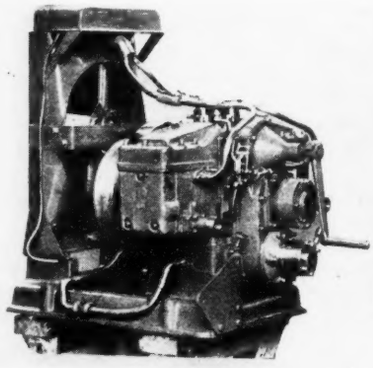
The Hayward Co., 50 Church St., New York, N. Y.



ROUND LEATHER BELTING

BELT hook is buried in groove and hook ends are clinched into opposite groove below surface of belt, thus leaving smooth, even and strong joint in this "Hook Groove" round leather belting.

Victor R. Clark Belting Co., 605 W. Washington Blvd., Chicago, Ill.



HORIZONTAL-OPPOSED DIESEL ENGINE

TWO-CYL., horizontal-opposed diesel engine weighs 280 lb., including a 60-lb. flywheel, and develops from 15 to 18 b.hp. at from 500 to 3,500 r.p.m. 30 in. wide x 18 long and $18\frac{1}{2}$ in. high. Manufactured under American patents of Victor Oil Engines, Ltd., Coventry, England, by:

Covic Diesel Engine Co., 443 Cotton Exchange Bldg., Los Angeles, Calif.

LOWER RATINGS IN VOLTAGE REGULATORS

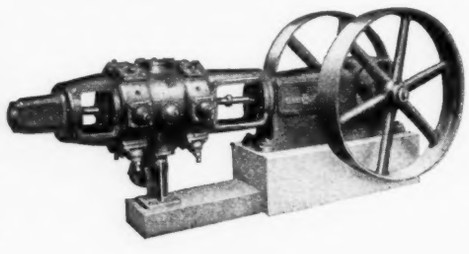
Two lower ratings in Type GDA generator-voltage regulators are now available for a.c. machines up to 375 kva. at 3,600 r.p.m., and smaller ratings at correspondingly lower speeds. Types are GDA-1M, and GDA-1.

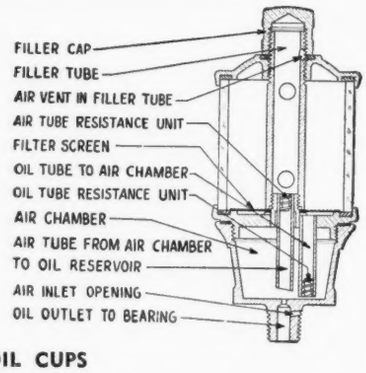
General Electric Co., Schenectady, N. Y.

AIR COMPRESSOR

CARBON packing ring replaces customary metallic piston rings so that no grease or oil is required for lubricating air cylinder of "Oilfreair," Class 3-ATC compressor. Tail rod and bearing carry weight of piston to preserve carbon packing ring. Collar on piston rod keeps oil out of air cylinder. Flat or multiple V-belt drive with overhead or horizontal motor mounting; or direct-connected synchronous motor, steam or countershaft.

Pennsylvania Pump & Compressor Co., Easton, Pa.





OIL CUPS

THERMATIC oil cup supplies constant, slow flow of oil due to normal increase in temperature of running bearings. Rise of 1.8 deg. F. causes flow. Fluctuation of room temperature will start occasional flow of oil, keeping bearings lubricated for more than a month without refilling. Oil expansion forces oil from bottom of oil chamber. Supply replenished from cup reservoir by gravity. Base inlet admits sufficient air to maintain pressure. 80-mesh filter screen at bottom of reservoir. Microflow cup supplies continuous flow in small adjustable quantities.

Resistance unit permits fine adjustment of flow. Larger opening in discharge valve for unhampered flow of oil. Grooved cylindrical plug through which oil passes to reach valve is adjustable.

Alemite Division of Stewart-Warner Corp., 1826 Diversy Pkwy., Chicago, Ill.

75-AMPERE VERTICAL WELDER

STABLE high-speed arc is produced by combining magnetic bridge as part of main pole assembly and spreading pole shoes well around holes in which stabilizer coils are embedded. 5-hp., fan-cooled, squirrel-cage motor on top of generator operated by push-buttons and equipped with no-voltage release and overload protection. Connections available for 110 to 550 volts or for special voltages of 2 and 3-phase, 60 and 50 cycles.

Harnischfeger Corp., Milwaukee, Wis.

AIR HOSE

STERLING cord air hose built like tire with cords laid in tough rubber cushions and isolated from adjacent plies. Said to give lighter weight, more flexibility, and greater resistance to pressure. Special compounded cover. Oil-resistant rubber in tube.

New York Belting & Packing Co., Passaic, N. J.

ELECTRIC UNIT HEATER

ELECTROMODE convection heater takes $\frac{3}{4}$ kw. and utilizes natural rise of warm air for circulation. Cast aluminum elements. Heating is done by means of calrod around which aluminum is poured. $4\frac{1}{2}$ in. wide, $9\frac{1}{2}$ in. long and 16 in. high, completely insulated, placed flush with wall.

Electric Air Heater Co., Division of American Foundry Eqpt. Co., 555 Byrkit St., Mishawaka, Indiana.

HIGH-PRODUCTION METAL-SPRAY GUN

MOGUL Model A for irons, Monel and steels and Model B for aluminum, nickel silver, brasses, bronzes and copper, steps up spraying speeds 200 to 300% while maintaining fine atomization. Difference in models is in interchangeable gearing. Single-valve control. Nozzle redesigned to get flames closer to wire by using hardened steel wire-guide tube, and pressures stepped up also if desired by operator. Designed for mounting in lathe; can be equipped with handle for portable use. Wire feed and gas mechanism, while attached to each other, are separately replaceable units, thus reducing replacement costs. All worms and gearshifts in wire feed mounted on annular ball bearings, in dustproof case, and running in fluid grease. Gas head a bronze casting and simultaneous control valve hard bronze. Housing, etc., aluminum alloy; feed, etc., nitrided steel. Fuel mixing done in a metering tube designed to minimize chances of flashback. Either wire or rod can be used, as gun can be lighted without wire in it. Danger of wire stoppage reduced by increasing power of air turbine and gearing. With acetylene at 25 lb., oxygen at 27, air at 80, Model A will spray 6 lb. per hr. of stainless steel, as compared with 2.4 for standard guns. With acetylene at 20 lb., and oxygen at 22, production drops off 13%; with acetylene at 15 and oxygen at 17, production drops off 25%. Average brass spraying speed 11.5 lb. per hr., as compared with 5.2 with standard gun.

Metallizing Co. of America, Inc., 1218 Long Beach Ave., Los Angeles, Calif.

ELECTRIC DRILLS

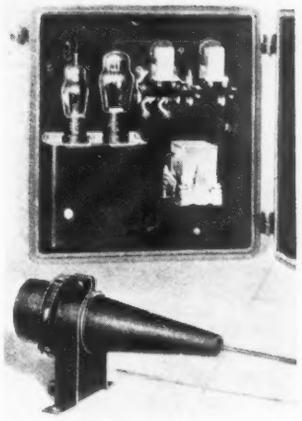
THREE models in extending line of electric drills are "Special Duty" ¼-in., and "Defender" ¼- and ½-in. drills. Defender drills have special alloy steel helical gears in die cast aluminum alloy frames. Three-jaw geared chuck and key. Double-pole momentary contact switch with lock for continuous operation inclosed in Bakelite. Model 40, special-duty tool, for drilling in light metals, and intermittent drilling in steel and cast iron. Die-cast aluminum-alloy frame.

Skilsaw, Inc., 3345 Elston Ave., Chicago.

COIL-WINDER DRIVE

OUTPUT speed is adjustable through foot-lever control while machine is running in this coil-winder drive. Automatic revolution counter on front of drive records revolutions of winding head, irrespective of direction of rotation. Asbestos-lined brake holds wire under tension and brings winding head to complete stop when foot lever is released. Drive pulley and brake on shaft running in babbitted, adjustable self-aligning bearings. Shaft connected through a flexible coupling to high-speed shaft of speed reducer. Driven from either lineshaft or by separate motor; when motor-driven, does not require special variable speed motor. Unit weighs 108 lb., and has input and output speeds 1,100 and 200 r.p.m. Drive pulley is 8 in. in diameter with 2½-in. crown face. Power required approximately ½ hp.

Ideal Commutator Dresser Co., 1025 Park Ave., Sycamore, Ill.



COMBUSTION SAFEGUARD

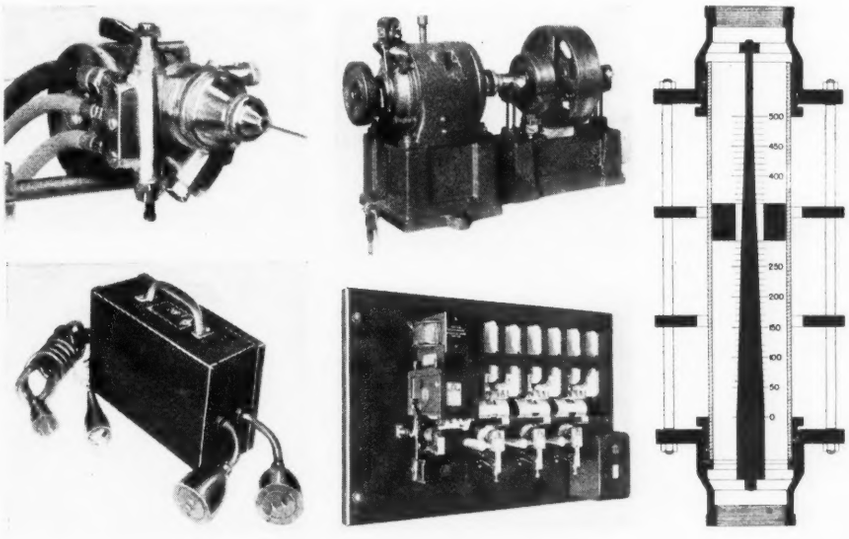
TWO types of relays and a flame-sensitive electrode are used in this system of combustion safeguard for any type of fuel-burning equipment. Thermionic tubes for rectification and amplification of power input which, when conducted from electrode input to ground, through the flame, operates relay unit, controlling operation and sequence of main fuel valve, etc. Cast-iron moisture-proof relay cases. For front of board or flush mounting. Uses standard radio-type vacuum tubes.

Brown Instrument Co., Division of Minneapolis-Honeywell Regulator Co., 4490 Wayne Ave., Philadelphia, Pa.

LARGER PORTABLE AIR-CONDITIONER

MODEL BA-100, companion to BA-75 portable air conditioner is 45½ in. long, 17¼ in. deep, and from 36 in. to 45 in. high, depending on adjustment of telescopic duct adapter fitted under window sash to bring in outside air. Cooling capacity greater than BA-75 while power consumption per unit of cooling has been reduced. New air-freshening device consists of hand-operated damper which can be opened in order to pump out room. Electric panel permits operation on 110 or 220 volts, a.c.

York Ice Machinery Corp., York, Pa.



TRANSFORMER FOR INSPECTION AND MAINTENANCE

PORTABLE transformer has primary cord, rubber-covered, which may be plugged into any 110-volt, 60-cycle circuit. Two secondaries to which extension cables are attached consist of vulcanized approved cable with special non-pull-out plugs. Secondary current rated at 32 volts. Designed particularly for service where inspection or maintenance must be done with electric illumination in moist or damp places, or in buildings permeated with explosive vapors or fumes.

Acme Electric & Mfg. Co., Cleveland, Ohio.

CIRCUIT BREAKERS FOR AUXILIARIES

SOLENOID-OPERATED, Type K, circuit breakers with high interrupting capacity, combine contactor and motor-starting characteristics. Latched-in type; do not drop out on loss of voltage. Trip-free closing mechanism. Butt-type contacts of non-welding, non-oxidizing alloy. Contact pressure provided by special laminated alloy springs which carry no current. Uses standard remote control wiring, 2- or 3-wire, momentary or maintained contact control.

I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Philadelphia, Pa.

FLOW METERS

STANDARD Rotameter utilizes bullet-shaped float in tapered tube to meter flow. When semi-opaque liquids, like oil, are metered, it is sometimes difficult to see float position. This taper-pole Rotameter, therefore, uses a straight tube with a tapered pole or metering pin, larger at bottom, in its center. On this pole and fitting inside the tube is a ring-shaped indicating element called a "rotor" which rises with increasing flow to increase orifice area. Since rotor moves up and down in close proximity to tube, it can be seen readily even in dark liquids. A variation for measuring flow of liquids which become very viscous near room temperature uses a hollow metering tube through which steam or hot water flows. Protecting case can be placed around meter to prevent heat loss from it.

Schutte & Koerting Co., 12th & Thompson Sts., Philadelphia, Pa.

THE ENGINEER'S BOOKSHELF

Diesels, Diesels, Diesels

HIGH-SPEED DIESEL ENGINES (2nd Edition)—*By Arthur W. Judge. Published by D. VanNostrand Co., Inc., 250 Fourth Ave., New York, N. Y. 347 pages, 5¼ x 8½ in. 284 illustrations. Cloth. Price $6.*

ELEMENTS OF DIESEL ENGINEERING, WITH QUESTIONS AND ANSWERS (1936)—*By Orville Adams, consulting diesel engineer. Published by The Norman W. Henley Publishing Co., 2 West 45th St., New York, N. Y. 450 pages, 6 x 9 in. 284 illustrations. Cloth. Price $4.*

DIESEL OPERATING GUIDE (1936)—*By Julius Rosbloom. Published by Diesel Engineering Institute, 443-445 Hoboken Ave., Jersey City, N. J. 544 pages, 5 x 7 in. Illustrated. Fabricoid cover. Price $5.*

A nation suddenly awake to the diesel is calling for books about them—or so book publishers hope—and the publishers are providing them, good, bad and indifferent. Scarcely a month passes without its additions to diesel literature. These three books are as divergent in treatment and presentation as their titles. The first is definitely an engineering treatise, written by an Englishman and based almost entirely on British and Continental practice. The second is aimed more at teaching diesel engineering in schools, hence is simpler and less technical in language. The third is an "operating guide," hence is simplicity itself. As between Adams and Rosbloom, however, as operating guides, this reviewer is inclined to favor the former. Its illustrations are not as good, but its grammar is better and its engineering somewhat nearer correct. Both have questions and answers.

This matter of illustrations and printing may sound out of place in a review of a technical book, but have you ever puzzled over a drawing of an injection nozzle, trying to figure out its arrangement from a blurred and indistinct drawing, or trying to read poorly printed text? Mr. Rosbloom's title page reads, "A practical book, written in comprehensive language," and that's just the trouble. Were his language less *comprehensive* and more *exact*, the book would be much easier to read and understand. Mr. Rosbloom deserves a palm for one thing, though, 2-color and fold-in illustrations that are large and distinct. The 2-color ones showing oil flow, etc., are particularly good.

Mr. Judge breaks his book into 25 chapters, including high-speed theory, description and operation, fuel injection and combustion, Ricardo swirl system, typical commercial cylinder heads, 2-cylinder H.S. engines, automobile and aircraft types, stationary and railway types, fuels and filters, care and maintenance (9 pages).

Mr. Adams has 20 chapters, beginning with elements of operation, definitions, efficiency factors, and going through nozzles, combustion chambers, fuel-injection systems, spark-ignition engines, fuels, pistons, cylinders and liners, piston rings, bearings, lubricating oils, air intake and exhaust systems, selection and installation, inspection, H.S. diesel development in Europe, truck and tractor engines, parts and operation and maintenance of automotive engines (4 chapters), field maintenance of automotive diesel auxiliaries and accessories (2 chapters).

Mr. Rosbloom's book has no general table of contents, but is broken into 14 sections, including types, maintenance, operation, oil, hydraulic (meaning pumps and piping), waste-heat recovery, auxiliaries, electricity ("with latest formulas in figuration of electrical requirements . . . "), accessories, timing and valve adjustments, formulas, automotive and tractor engines, diesel-electric drives for locomotives and railcars, management and construction detail, "Monel metals and copper for diesel services."

Electrical Measurements

ELECTRICAL MEASUREMENTS IN PRINCIPLE AND PRACTICE (1936)—*By H. C. Turner, Governor of Royal Technical College and E. H. W. Banner. Published in England, distributed in America through Instruments Publishing Co., 1117 Wolfendale St., Pittsburgh, Pa. 380 pages, 5½x8¾ in. Cloth. 219 figures. Price $4.50.*

Practically complete coverage of the measurement of all electrical quantities is secured by eliminating most of the mathematical proofs in this well-illustrated book. It is divided into five parts: (1) Units and Standards; (2) Instruments; (3) Measurement of Electrical Quantities; (4) Measurement of Electrical Properties of Apparatus, and (5) Indirect Electrical Measurements. This type of text is not readily adaptable to beginners, yet serves as an excellent reference for electrical engineers.

Engineering Law

LEGAL AND ETHICAL PHASES OF ENGINEERING (1936)—*Dr. C. Francis Harding, head, and Prof. Donald T. Canfield, School of Electrical Engrg., Purdue University. Published by McGraw-Hill Publishing Co., 330 West 42nd St., New York, N. Y. 432 pages, 6x9 in. Cloth. Many diagrams and references. Price $4.*

"Unfortunately the young engineer is naturally inclined, as the result of his meticulous laboratory measurements and accurate mathematical analyses, to see the trees and their exact dimensions in the foreground and to permit them to blot out the vast landscape and . . . the broad forest vistas beyond." So write these authors in pointing out the need for broader education in modern business conditions for the embryo engineer. Too often the engineer must learn through bitter experience that his exact calculations go for naught against the approximations and ready commercial sense of competitive business.

It is in the effort to point a way through the legal and ethical maze of business relationship that this book was written. Who gets a patent and how? To whom does it belong? What is a contract? And so on, through the questions we usually learn about only after we get burnt. This text is in three general sections, Legal Status (contracts), The Engineer and The Law (specifications, estimates, witnesses), Auxiliary Legal Relations (patents, copyrights, sales agreements, insurance and compensation), The Engineer and Society (public relations, ethics). Appendices give typical proposal forms and specifications, uniform negotiable instruments and laws governing them, Indiana Workmen's Compensation Act, and several actual specifications.

BRIEF REVIEWS

PAPE-SWIFT BOILER REFERENCE BOOK, Third Volume, (1936). *Compiled by Oscar H. Pape. Published by John S. Swift Co., Inc., 105 South Ninth St., St. Louis, Mo. 324 pages, 5½x8¼ in. Paper. Completely tabular. Price, $1, plus postage.*—Boiler rating data from 42 manufacturers of steam-heating boilers.

WATER POWER RESOURCES OF CANADA (1936). *Published as Bulletin No. 1879 by The Dominion Water Power and Hydrometric Bureau of the Department of the Interior of Canada. Free.*—Annual review, supplies information in condensed form on total amount of available and developed power, current progress and developments, utilization of developed power, past and future growth in development, capital invested in water-power development, and coal-equivalent of developed water-power.

METHODS FOR DETERMINING GRINDABILITY OF COAL (1936). *Published as Bulletin R. I. 3301, by U. S. Bureau of Mines, Department of Interior, Washington, D. C. 16 mimeographed pages, 8x10½ in. Paper. Many tables. No price given.*—Describes tests conducted under sponsorship of Subcommittee VII on Pulverizing Characteristics of Coal, a subcommittee of Committee D-5 on Coal and Coke, of American Society for Testing Materials.

MANUAL OF AMERICAN STANDARDS (1936). *Published by American Standard Association, 29 West 39th St., New York, N. Y. 12 pages, 8x10½ in. Paper. Free.*—Indexed list of engineering and industrial standards and safety codes approved by A. S. A.

SHOW SCHEDULE (1936). *Published by Exhibitors Advisory Council, Inc., 330 West 42nd St., New York, N. Y. 10 mimeographed pages, 8½x11 in. Paper. Price, $2.*—Special Supplement No. 1, schedule of shows, expositions and fairs to be held from March to December, 1936.

CURRENT HYDRAULIC LABORATORY RESEARCH IN THE U. S. (1936). *Published as Hydraulic Laboratory Bulletin IV-7, by the U. S. Department of Commerce, National Bureau of Standards. Washington, D. C. 106 mimeographed pages 8½x11 in. Paper. No price given.*

STEEL HOOPS FOR PLATTE VALLEY

Ring girders for steel penstock of $7,500,000 Platte Valley, Nebraska, PWA, development. Project will include 25,000-kva. hydro plant, 220-mile transmission line, 2 reservoirs and 75 miles of irrigation canals

POWER LINES

New Diesel Insurance Rates Announced

NEW coverage and rates for insurance on diesel engines, in many cases representing substantial reductions from rates previously in effect, have been announced by Boiler & Machinery Dept. of National Bureau of Casualty & Surety Underwriters, effective May 1, 1936. Promulgation of the new rules follows closely adoption by the Diesel Engine Manufacturers' Assn. of changes in "Standard Practices," and resulted from a series of conferences between committees of the two organizations.

Some years ago when the diesel was relatively new and characteristics of design not so well understood, there were some misapplications involving inadequate power capacities, improper cooling systems and poor maintenance. These gained wide attention, and some engineers formed the opinion that diesel equipment was inherently prone to a higher frequency of enforced shutdowns than was steam equipment.

Actually there is no reason why diesel engines should not show as favorable service experience as steam apparatus, in cases where the diesel is properly selected for the character of service and load requirements, where it is correctly installed with an adequate, reliable cooling system, as well as necessary auxiliaries, and where the system of maintenance is kept up to a proper standard.

In the new "Standard Practices," the manufacturers stress the advisability of installing closed cooling systems, having found that many troubles — cracked cylinder heads, cracked pistons, stuck pistons, etc.—have been due to improper cooling conditions. Use of the open cooling system, in which raw water circulates through the engine and goes directly over the cooling tower or through the spray pond, is usually the cause of such accidents. Experience has shown that even though the make-up water in an open system goes through a softening process, this practice does not eliminate all breakdowns.

The plan of rating inaugurated by the insurance companies contemplates rate differentials for the following four classes of diesel engines:

Class 1. Engines manufactured in 1925 or later and provided with a closed cooling system.
Class 2. Engines manufactured prior to 1925 and provided with a closed cooling system.
Class 3. Engines manufactured in 1925 or later and provided with an open cooling system.
Class 4. Engines manufactured prior to 1925 and provided with an open cooling system.

Under the new plan, rates for Class 1 engines are, for the most part, considerably lower than under the old plan, although the changed basis of rating, from cylinder number and size to horsepower capacity, prevents definite comparison except in individual cases. For the other three classes, rates may be either higher or lower than previously, but the general trend is to produce lower rates for Class 2, higher rates for Class 4 and very little change for Class 3.

The engineering and inspection service which customarily is furnished by the insurance companies is available in connection with internal-combustion engines.

Benson Boilers on Steamships

REVIEWING the present position of marine steam boilers before the British Institution of Naval Architects, Engineer Rear-Admiral W. M. Whayman gave particulars of the Benson high-pressure boilers on the steamship "Potsdam" (*The Engineer,* April 10, 1936). This ship has four Benson 1,325-lb., 878-deg. boilers totaling 14,632 sq.ft. of heating surface and evaporating 246,400 lb. per hr. under normal load. Superheater and air heater heating surfaces total 10,760 sq.ft. Evaporation is 16.8 lb. per sq.ft. of boiler heating surface per hr.

This ship is one of three recently put in service by Norddeutscher Lloyd for Eastern service. The "Scharnhorst" and the "Gneisenau" are the other two. They have Wagner boilers working at 737 lb. per sq.in. with 878 deg. F. final steam temperature. The figures quoted above for the "Potsdam" indicate the increase in boiler rating to be expected, particularly from the forced circulation of the Benson boiler. There also appears to be an advantage in weight, space and fuel economy. All three vessels are now in service, and experience with them, as well as with the "Uckermark," which also has a Benson boiler, will determine the reliability of these higher-pressure plants.

Other vessels in which higher pressures and temperatures have been tried include the "Tannenberg," with two Wagner boilers at 850 lb. and 860 deg.; the "Kertesono," with a Sulzer single-tube boiler; the "Conte Rosso," with a Loeffler boiler replacing one Scotch boiler, and another vessel with a Velox boiler. The "Conte Rosso" boiler is to operate at 1,850 lb. and 890 deg. F., and is expected to increase fuel economy 9%, and with an additional turbine set being added to each shaft, to increase shaft hp.

Choose Papers for World Power Conference

A PARTIAL list of American authors who will present papers at the World Power Conference in Washington, D. C., Sept. 7-12, 1936, has been announced. The general subject will be the economies of power. Titles and authors, insofar as the latter have been selected, are:

Power Resources, Development and Utilization—Central Statistical Board.
Trends in the Utilization of Power Resources—Dr. Harlow S. Person, consulting economist, president of Taylor Society.
Internal Use of Statistics—Central Statistical Board.
Production and Distribution of Coal and Coal Products—Isador Lubin, Commissioner of Labor Statistics, in collaboration with National Coal Association.
Production and Distribution of Petroleum and Its Products—Joseph E. Pogue, consulting engineer, American Petroleum Institute.
Production and Distribution of Gas—Judson C. Dickerman, Federal Trade Commission, and American Gas Association.
Organization of Private Electric and Gas Utilities—Robert E. Healey, S. E. C.; James F. Fogarty, president North American Co.
Public Regulation of Private Electric and Gas Utilities—James C. Bonbright, trustee, New York Power Authority; William E. Mosher, Syracuse University; John E. Zimmerman, president, United Gas Improvement Co.
Organization of Publicly-Owned Utilities—E. F. Scattergood, general manager, Los Angeles Bureau of Power & Light.
Planning for the Conservation of Natural Resources—Stuart Chase, economist; W. S. Finlay, Jr., president, West Penn Electric Company.
Conservation of Coal Resources—U. S. Bureau of Mines.
Conservation of Petroleum and Natural Gas—U. S. Bureau of Mines.
Planned Utilization of Water Resources—Arthur E. Morgan, chairman, T.V.A.; Harrison G. Roby, Byllesby Engineering and Management Corp.
Utilization of Small Water Powers—Dr. H. H. Bennett, chief, Soil Conservation Service, U. S. Department of Agriculture.
Regional Integration of Electric and Gas Utility Facilities—Basil Manley, vice chairman, Federal Power Commission; George N. Tidd, president, American Gas & Electric Co.
Rationalization of Distribution of Electrical Energy and Gas—J. D. Ross, S.E.C.; Norman R. Gibson, vice-president, Niagara-Hudson Power Corp.

Rural Electrification—Dr. H. A. Morgan, director, T.V.A.; Hudson W. Reed, United Gas Improvement Co.
National Power and Resources Policies—George Souls, editor, "The New Republic"; Floyd L. Carlisle, chairman, Niagara Hudson Power Corp.

Formal acceptances have been received from Algeria, Argentine Republic, Bolivia, Bulgaria, Chile, Costa Rica, Dominican Republic, El Salvador, France, Germany, Guatamala, Honduras, Italy, Irish Free State, Lithuania, Luxemburg, Nicaragua, Portugal, Roumania, Sweden, and Uruguay. Participation is promised, although official action is yet to be taken, by: Austria, Belgium, Brazil, Canada, China, Czechoslavakia, Denmark, Great Britain, Holland, Japan, Latvia, Mexico, Norway, Poland, Switzerland, Union of Socialist Soviet Republics, and Yugoslavia.

Foreign delegates will see notable developments in their particular branch of the power field in a series of "study tours" before and after the Conference itself. One day in each tour will be devoted to round-table discussion led by experts.

NEWS NOTES

POWER PROGRAM at A.S.M.E. Meeting in Dallas, Tex., June 15-20, will consist of two or three sessions covering natural gas for central stations, operating experiences with pulverized lignite, operating features of a 1,450-lb. steam plant, automatic combustion control for burning certain types of fuel, and boiler-water problems. A joint session with the Process Industries Division will be devoted to power problems in the sulphur industry.

NINTH National Oil & Gas Power Meeting of A.S.M.E. will be held at University of Michigan, Ann Arbor, Mich., June 24-27, sponsored by Oil & Gas Power Division and Detroit section of Society.

N. Y. STATE BOARD OF EXAMINERS FOR PROFESSIONAL ENGINEERS will probably be unable to handle the 3,000 applications for June examinations which were filed before April 1. Many of these may have to be held over for examinations in January, 1937. Any one applying after Jan. 1, 1937, will be required to take full written examination (two days) without partial exemption. Candidates who are not graduates of approved engineering schools will have to show twelve years of engineering experience before admission to the examination. Since enactment of the Registration Law in 1920, New York State has licensed 13,100 professional engineers and 4,900 land surveyors, and 3,500 men licensed to practice both. In fifteen years the total loss by mortality, retirement, etc., has been only 24%. Past records of the Board indicate that only 60% of applicants have been successful.

CONTRACTS on PWA jobs for heating and ventilating systems have amounted to approximately $3,500,000 in direct awards, according to a statement by Carl H. Bauer, state PWA director for Illinois, before a meeting of the Illinois Chapter of A.S.H.V.E.

UNIVERSITY OF ILLINOIS third "short course" on coal utilization will be held on the campus June 9, 10 and 11. New developments in stokers will be discussed by B. M. Guthrie, chief of Stoker Division, Fairbanks, Morse & Co., Chicago, Ill. L. A. Shipman, combustion engineer of Southern Coal & Coke Co., Knoxville, Tenn., and J. G. Worker, general sales manager of American Engrg. Co., Philadelphia, will discuss ultilization of coal in small and large plants. Profs. A. C. Callen and D. R. Mitchell, who are in charge of the course, will talk on types of solid fuel and coal sampling.

EDISON ELECTRIC INSTITUTE, 420 Lexington Ave., New York, N. Y., will hold its fourth annual convention in St. Louis, Mo., June 1 to 4. Business sessions will be held in Opera House of new Municipal Auditorium.

MADISON SQUARE GARDEN, New York, is to be air-conditioned at once, thus making it available for summer as well as winter use. The refrigerating plant now used only for freezing the ice when the Garden is used for hockey, etc., will thus find year-around use. It will be one of the largest air-conditioning jobs thus far undertaken.

PERSONALS

ELY C. HUTCHINSON, editor of *Power* from 1930 to 1933, has joined J. G. White Engrg. Co., 80 Broad St., New York, N. Y. Mr. Hutchinson was formerly connected with with Cramp-Morris Industrials, Inc., and was president and general manager of Pelton Water Wheel Co., San Francisco, from 1926 to 1929. He was president of Edge Moor Iron Co. from 1933 to 1934 and is chairman of the A.S.M.E. Power Test Code Committee for Hydraulic Prime Movers.

PROF. DR. MAX JAKOB, who until his retirement this year was scientific adviser to the Society of German Engineers (VDI), is making an extended visit to this country, during which he is delivering lectures on heat transfer. April 22, 23, and 24 he spoke to the Metropolitan Section, A.S.M.E., on "General Aims of Steam Research and Calorimetric Experiments on Latent Heat and Volume of Saturated Steam at High Pressure," "Evaporation as a Problem of Heat Transfer," and "Condensation as a Problem of Heat Transfer." His lecture tour is sponsored by Harvard Engrg. School, M.I.T., Univ. of Ill., Princeton, Univ. of Calif., Stevens Institute, Columbia, Cooper Union, Brooklyn Poly, Pratt, Newark School of Engrg., Westinghouse, GE, and the A.S.M.E.

THOMAS I. PARKINSON and GEORGE A. RANNEY were elected directors of Westinghouse Electric & Mfg. Co., at annual meeting in East Pittsburgh.

JOHN M. LASSELS, consulting mechanical engineer of Swarthmore, Pa., has been appointed associate professor of mechanical engineering at M.I.T.

RUSSELL K. ANNIS, consulting engineer and former chief engineer of Hydraulic Dept., Fairbanks, Morse & Co., Beloit, Wis., has moved his office to Ashville, N. C.

H. K. KUGEL, former chief smoke inspector of Cleveland, Ohio, has recently been appointed smoke abatement engineer of the District of Columbia.

WALTER E. HAWKINSON has been appointed treasurer of Allis-Chalmers Mfg. Co., Milwaukee, Wis., succeeding the late Raymond Dill.

ARTHUR D. DURGIN, 131 Clarendon St., Boston, Mass., is now representing Connery Construction Co., Philadelphia, Pa.

F. W. BUNTING and HAROLD A. SCHLEIDER have joined the Engrg. Dept., Northern Equipment Co., as inspection engineers.

OBITUARIES

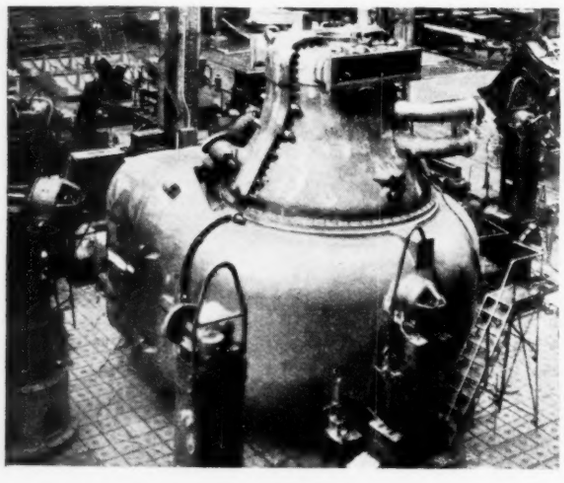
HARRY U. HART, vice-president and chief engineer of Canadian-Westinghouse Co., Ltd., died March 15. After joining Westinghouse Electric & Mfg. Co. in 1893 as a student apprentice, Mr. Hart was appointed designing electrical engineer for French Westinghouse Co. in 1899, later being appointed chief engineer and remaining for five years with that company. He was appointed chief engineer of Canadian Westinghouse Co. in 1905, general manager and chief engineer in 1923, and vice-president and chief engineer in 1928.

ALEX GIRTANNER, senior member of National Conveyors Co., died March 28.

LEO W. MACKINNON, 57, stationary engineer at Washington Real Estate Bldg., Providence, R. I., since 1924, died April 2.

WILLIAM ROBERTS GAYLORD, 74, engineer for Consolidated and Colonial Cold Storage plant in Provincetown, Mass., died April 16.

THOMAS A. BARRY, 49, for the past 23 years connected with the sales engineering staff of G.E. in Boston, died March 30.



FOR DETROIT

Exhaust head and shell for the first of the new 60,000-kw. turbine-generators for Connors Creek Station of Detroit Edison Co. General Electric is rebuilding three 20,000-kw. and two 30,000-kw. units to make 30,000-kw. units, which with two 60,000-kw. sets, will increase station capacity from 180,000 kw. to 330,000 kw., dropping heat rate at the same time from 19,000 B.t.u. to well under 13,000. Steam will be at 600 lb. and 825 deg. instead of 220 lb. and 600 deg.

Generated or Purchased Steel-Mill Power

MARCH 18, the Chicago Section of the Association of Iron & Steel Electrical Engineers held its largest dinner meeting of the season. The attendance exceeded 300. Owing to the increasing power demands of the modern mill and the enormous investments required, the subject of the evening was of such vital interest as to attract participants from Pittsburgh and other points east. Following the paper and its discussion, two most interesting sound movies were presented, one showing the Carnegie-Illinois 43-in. continuous hot-strip mill at the McDonald Works and the other illustrating the operation of the modern continuous hot- and cold-strip mill of Ford Motor Co.

J. W. Bates, electrical engineer of American Sheet & Tin Plate Co., Pittsburgh, was the speaker. As an introduction to the subject, reference was made to the wide discrepancies that might occur between actual and computed costs, the fallacy of using average costs over a period of years, and the importance of making comparative analyses of purchased and generated power on exactly parallel bases. Owing to the many variables arising in such a comparison, the study in the paper was simplified by limiting it to a particular problem, with the thought that the method used could be adapted to the solution of other problems.

To show the background of the study, the author analyzed the character of the electric load of broad strip mills requiring a generating capacity of 50,000 kw., particularly the characteristics affecting the required generating capacity to carry these loads. He continued with a graphic analysis of both utility purchased power and power generated either from coal-fired or waste-heat steam stations. For generated power, constant and variable costs and their development were considered. Under purchased current, the author discussed utility rate structures and some of the "provisions" occurring in power contracts, such as instantaneous demands, minimum bills and off-peak clauses. Having established the method and the conditions, specific comparisons were made with the following general conclusions:

"That for coal-fired stations it is practical for steel companies and other large industrial plants to buy power with advantage.

"That for waste-heat fired stations it is not normally practical for these plants to buy large blocks of power to advantage, except under special conditions.

"That each situation is a separate problem; local conditions of availability of attractive utility rates, investment costs, and the possibility of using high steam pressures and temperatures without introducing too many complications into existing boiler houses all have to be considered for each particular problem."

Participants in the discussion emphasized the importance of the steel industry in the national power picture. The total power consumption approximated 10% of the electrical energy generated by all utilities in the country. Of the 9½ billion kw.-hr. used annually by the steel industry, 6 billion kw.-hr. were generated and 3½ billion kw.-hr. purchased. Consumption averaged 170 kw.-hr. per ton of steel produced.

Although each installation required special study, it was generally conceded that the trend in large steel companies was toward purchased current, so that they might devote all of their energies and resources to the manufacture of steel. It was essential that cooperative study should produce a contract that would be profitable to both parties. Long-term contracts to protect the utilities on generating capacity were essential, and coal and tax clauses to permit variation in rate.

Consensus of opinion agreed that it might pay to generate power when the mill operated at full rate. When operating at partial rate with shutdown periods, it would be profitable to purchase current. At partial load the fixed charges were a much larger factor in the cost of power than the generating cost. With a generating plant these fixed charges cannot be avoided. A large investment is required that cannot be unloaded. If current is purchased with a variable demand rate from month to month according to production, a large saving is possible.

All-Welded Plant For Diesel Locomotives

THE nine buildings in the diesel-electric locomotive works constructed by Austin Co. for Electro-Motive Corp., a division of General Motors Corp., at McCook, Ill., are all arc-welded.

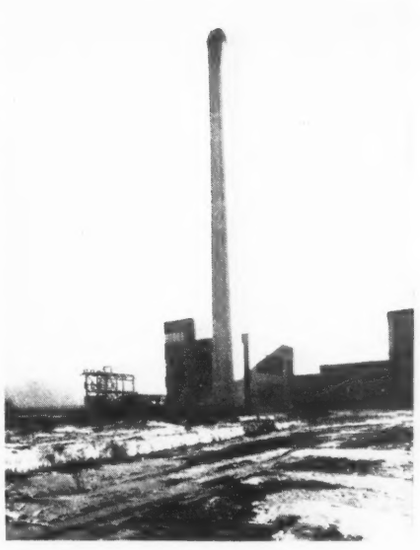
Power from two Winton diesels (units on test before installation in locomotives), while sufficient to supply the needs of the entire plant, will only be used to operate the cranes. Power for manufacturing is purchased.

In the main erecting aisle, a 200-ton, all-welded, electric traveling crane, weighing 205 tons (the largest of its kind ever built), is equipped with four 50-ton hooks.

Individual transformers on alternate columns along the main aisle take 3-phase, 440-volt current on the primaries to give 110 and 220 volts, single-phase, on the secondaries. Besides supplying power, these transformers feed 1,000-watt lamps in aluminum reflectors on the roof trusses.

Sewage from the plant falls into an octagonal basin inside the base of the power-house stack (which thus serves a dual purpose), and is pumped from this basin into a nearby sewage-disposal plant.

The boiler house which supplies steam for heating all manufacturing buildings, including the main office, and also for drop hammers and water heating, is a single-aisle structure 50 x 60 ft., housing two 3,320-sq.ft., three-drum B.&W. Stirling boilers installed to supply a demand for 20,000 lb. per hr. of steam at 100 lb. pressure. They are fired with Illinois and Indiana coals, burnt on Combustion Engineering Type E center-retort underfeed stokers 9 ft. long and having an effective grate area of 71.25 sq.ft. Stokers are designed to operate at 150% rating continuously with an overall efficiency of 74.5%, and for peak loads of 200%. Bigelow unit suspended wall construction is used for both the front and rear walls of the boiler setting, with silicon-carbide faced walls in the lower 12 in. of the bridge wall at the clinker line. The side walls are 18-in. solid refractory faced with 9 in. of first quality A. P. Green Missouri brick in the furnace zone only.



Boiler settings are undercut in the rear, and Buffalo Forge motor-driven forced draft fans are placed in this space directly to the rear of the boiler. Inlets to the fan are provided with vanes for distributing air into the fan wheel and each outlet is provided with a balanced type ball-bearing damper controlled by a Hagan regulator.

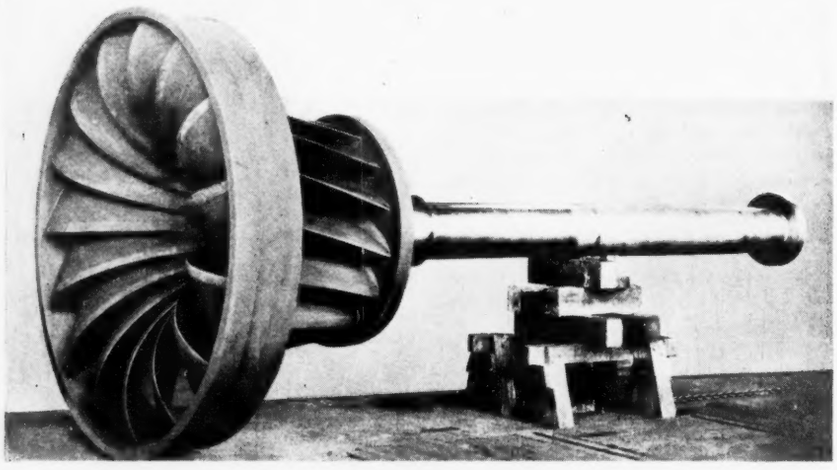
Draft is provided by a radial brick chimney built by Alphons Custodis, which is 175 ft. high and 90 in. in diameter at the top.

Republic steam flow meters on the boiler column at the front of each boiler record uptake temperature as well as steam flow. Draft gages directly over the steam flow meter indicate windbox and furnace pressures.

Two 10 x 6 x 10-in. Worthington horizontal duplex boiler feed pumps are equipped with Hills-McCenna forced-feed mechanical lubricators. Swartwout feed water regulators and pump governors are used. A Cochrane direct contact type open feed water heater is mounted directly above a welded steel hotwell 4 ft. in diameter by 8 ft. long. Very little make-up water is required, as practically all condensation from the plant is pumped back to this heater well.

The Palmer-Bee coal-handling equipment has a capacity of 40 tons per hour. Coal discharge from a track hopper to a 24-in. reciprocating plate feeder which discharges to a vertical bucket elevator. The bucket elevator in turn discharges to a drag chain distributing conveyor over the coal bunker.

To the east of the boiler house a pump house has been erected directly over a 1,600-ft. deep well, and contains the deep-well pump, a hydro-pneumatic tank, and an electric-driven fire pump. The Peerless deep-well pump has a capacity of 300 g.p.m., and is driven by a vertical, hollow-shaft motor. It is automatically controlled and arranged to cut out at 50 lb. pressure and in at 35 lb. pressure. A 1,000-gallon Worthington centrifugal fire pump takes its suction from an adjoining 200,000-gallon concrete storage reservoir and discharges to the underground fire line serving the sprinkler systems and hose hydrants. Pumps supplying cooling water to the engine room and also an emergency pump supplying water to the underground line likewise draw from the reservoir.



RUBBER-COVERED TURBINE BUCKETS

To protect the $\frac{7}{8}$-in. steel buckets on this 15-ft. diam. waterwheel from cavitation, Goodrich gives them one coat of rust-inhibiting primer followed by a coat of self-vulcanizing cement before applying three coats of a liquid rubber compound. The protective covering is 0.003 in. thick

STRAWS

Pointing the way business winds blow

UNITED ILLUMINATING CO., New Haven, Conn., has let building contract to Mott Construction Co., New Haven, for addition to generating plant at Steel Point, Bridgeport. Two high-pressure boilers and auxiliary equipment will be installed. Cost over $250,000. Westcott & Mapes, New Haven, architects and engineers.

PERRY, N. Y., is considering special election to vote bonds for $250,000 for electric power plant. L. C. Reynolds, Geneva, N. Y., consulting engineer.

NIAGARA ALKALI CO., Buffalo Ave., Niagara Falls, N. Y., will make extensions in power house, including two boilers, pumping machinery and auxiliary equipment. Cost over $50,000. Jenks & Ballou, Industrial Trust Bldg., Providence, R. I., consulting engineers.

CENTRAL IRON & STEEL CO., S. Front St., Harrisburg, Pa., plans addition to power plant, to include installation of boilers, turbines and auxiliary equipment. Cost over $150,000.

SLOAN & ZOOK CO., 101 Main St., Bradford, Pa., oil refiner, plans pumping station for development of oil properties in Venango County, including gasoline engine-driven pumping units with accessories, to cost over $500,000.

South

PUBLIC WORKS BRANCH, Treasury Dept., Washington, D. C., plans heat, light and power plant in 16-story Federal building at Spring, Temple and Main Streets, Los Angeles, Calif. Bids will be asked soon. Appropriation of $6,250,000 has been authorized.

CONSTRUCTION SERVICE, Veterans' Administration, Washington, D. C., will receive bids until May 19 for refrigerating and ice-making plants, ventilating and air conditioning equipment, electric elevators, and water and light utilities, etc., for Hospital Bldg. No. 76, Bath, N. Y.

CHARLES E. KREBS, INC., Charleston, W. Va., will make surveys welded steel pipeline for natural gas supply to Pineville and Middlesboro, Ky., from French Lick by a company being organized by William T. Lively, Charleston. Line gathering system and distributing lines will cost about $500,000.

OCALA (Fla.) GAS CO. will double capacity of its plant to take care of 2,000 more consumers. J. D. Wilkes, manager.

DELAND (Fla.) CITY COMMISSION has approved ordinance providing for revenue certificates to construct electric generating and distribution system to cost approximately $468,000. PWA has granted $117,000.

GULF POWER CO., Pensacola, Fla., will air-condition its general offices as part of $25,000 improvement program.

T. R. MILLER MILL CO., Brewton, Ala., has plans expansion in lumber mill, including new boiler plant and engine house to cost $100,000.

PANAMA CITY, FLA., city commission has passed an ordinance providing for the construction of additions and improvements in the city water works system and raising of $50,000 to be repaid through revenues received by the water works.

HATTERAS DEVELOPMENT CO., Hatteras, N. C., plans steam power plant to cost over $80,000, with equipment. Permission has been applied for.

Mid-West

EL DORADO, ARK., plans municipal electric plant, with substation and distribution lines. $575,000 being arranged through Federal aid. George R. Crosley, mayor.

HUTCHINSON, MINN., has contracted for municipal power plant as follows: Construction, Electric Equipment Co., Des Moines, Iowa, $11,500; plant equipment, McIntosh-Seymour engine, Donovan Construction Co., St. Paul, Minn., $114,367; switchboard and accessories, Electric Engineering & Construction Co., Des Moines, Iowa. Buell & Winter Engrg. Co., Sioux City, Iowa, consulting engineer.

JACKSONVILLE, ILL., will build electric power plant to cost about $420,000, of which part will be secured through Federal aid.

BOARD OF EDUCATION, Escanaba, Mich., asks bids in May for boilers and accessories at Washington and Jefferson schools; also for automatic temperature control apparatus, unit ventilators and other equipment. Wallsworth & Trickler, Marinette, Wis., consulting engineers.

ASHLEY, IND., plans call for bids for electric-operated pumping machinery and auxiliary equipment for waterworks station to cost about $95,000. Lennox & Matthews, Architects 'and Builders' Bldg., Indianapolis, consulting engineers.

TRAER, IOWA, is considering extensions in municipal electric plan. Surveys and estimates are under way. D. M. Shively, engineer.

CONTINENTAL OIL CO., Ponca City, Okla., plans 8-in. welded-steel pipeline from oil field near Ada, Okla., to Oklahoma City, about 110 miles, for crude-oil transmission. Includes pumping stations along route. Will cost close to $1,000,000.

UNION SULPHUR CO., Sulphur, La., will lay 6-in. welded-steel pipeline from oil field at Old Town Bay, La., to Calcasieu River, near Lake Charles, La., about 15 miles. Cost close to $100,000.

HOISINGTON, KAN., has contracted Chapin Construction Co., 243 S. Crestway, Wichita, for power plant to include 3 diesel generators and cost $135,000. W. B. Rollins & Co., Railway Exchange Bldg., Kansas City, Mo., consulting engineers.

DESHLER, NEB., has contracted Fairbanks, Morse & Co., Chicago, Ill., for generator and other equipment for electric plant. Robert Fulton, 2327 S. 19th St., Lincoln, consulting engineer.

U. S. ENGINEER OFFICE, Vicksburg, Miss., will receive bids until May 14 for diesel generating set with accessories (Circular 247).

BOARD OF EDUCATION, Bay City, Mich., plans central heating plant in multi-story junior high school to cost over $1,000,000. Joseph C. Goodeyne, Bay City, architect.

OCONTO, WIS., plans motor-driven pumps, gasoline engine units for standby, elevated tank and other equipment in waterworks. To cost $175,000, including purchase from private interests.

CHEVROLET MOTOR CO., Detroit, Mich., has asked bids on addition to power house at works on E. Euclid Ave. to cost close to $85,000. Albert Kahn, Inc., New Center Bldg., architect and engineer.

ST. LOUIS, MO., has low bid from Heine Boiler Co., St. Louis, for boilers and accessories for sanitarium at $98,042. Low bid for stokers submitted by Laclede Stoker Co., St. Louis, at $19,732, and for coal-conveying system, from General Conveyor Mfg. Co., St. Louis, at $37,096.

ENID (OKLA.) ICE & FUEL CO., has contracted McMillan Construction Co., Enid, for

ice-manufacturing and cold storage plant to cost about $100,000, with equipment. R. W. Shaw, Enid, architect and engineer.

PANHANDLE EASTERN PIPELINE CO. has ordered six 200-hp. vertical gas engine-driven electric generators from Cooper-Bessemer Corp. to provide auxiliary power for main line compressor stations to pump natural gas from Texas to Detroit, for which twelve 1,300-hp. and two 1,000-hp. gas engine compressors are now being built by Cooper-Bessemer.

WARREN PETROLEUM CO., Tulsa, Okla., has ordered eight 1,000-hp. horizontal, twin-tandem gas engine-driven compressors for gasoline extraction and gas compression station on property of United Gas Public Service Co. in Rodessa (La.) oil and gas field.

ROCHESTER, MINN., has contracted Westinghouse Electric & Mfg. Co. for turbo-generator for power plant at $177,600; Foster-Wheeler Corp., New York, N. Y., for condenser at $41,852. Burlingame & Hitchcock, Sexton Bldg., Minneapolis, Minn., consulting engineers.

WESTBROOK, MINN., plans electric power plant and will arrange bond issue as soon as cost has been determined. T. V. Peterson, village clerk, in charge.

KRAFT-PHENIX CHEESE CORP., 400 N. Rush St., Chicago, Ill., will build five-story cold storage and refrigerating plant on East Stephenson St., Freeport, to cost about $125,000.

RED BLUFF WATER POWER CONTROL DISTRICT, Orla, Tex., has contracted S. Morgan Smith Co., York, Pa., for hydro-turbine at $41,770, and General Electric Co. for generator at $54,495. Vernon L. Sullivan, engineer.

BRISTOW, OKLA., is considering bond issue of $289,000 for electric power plant and distribution lines.

INTERNATIONAL HARVESTER CO., 606 So. Michigan Ave., Chicago, Ill., has contracted A. G. Samuelson, 320 S. Clairmont St., Springfield, Ohio, for power plant at motor truck works on Lagonda Ave. Awards for boilers, stokers, forced-draft equipment and accessories will be made soon. Cost over $100,000. W. H. Kruger, company engineer, in charge.

CURRENT RIVER POWER CO., 1105 R. A. Long Bldg., Kansas City, Mo., has applied for permission to construct series of power dams on Current River in Ripley and Shannon Counties to cost about $2,000,000.

SEBRING COAL CO., Sebring, Ohio, plans purchase of coal-handling equipment in connection with new tipple to cost $40,000.

DETROIT EDISON CO., Detroit, Mich., will use blast furance gas for fuel at Delray plant, and plans installation of 2,700 ft. of 36-in. welded-steel pipeline from steel works.

RICHMOND, IND., plans extensions in electric power plant to cost about $35,000. Fallon & Mills, First National Bank Bldg., consulting engineers.

MID-CONTINENT PETROLEUM CORP., Tulsa, Okla., plans boiler plant at refinery near Holdenville, Okla. Will cost about $100,000.

STATE WATER CONSERVATION BOARD, Helena, Mont., plans gas engine-driven pumping plants for irrigation project at Saco. Steel pipeline will be constructed from natural gas fields in Saco district. Will cost about $250,000. $10,000 has been authorized for surveys. J. S. James, Helena, state engineer, in charge.

West Coast

SAN DIEGO (Calif.) CONSOLIDATED GAS & ELECTRIC CO. will Lindeweld 15 miles of 2½- 3-in. pipe to carry natural gas at 400 lb. pressure from Carsbad to Escondido, Calif.

CORONADO (Calif.) WATER CO. plans electric-operated pumping plant for new source of water supply in Tijuana Valley near Palm City, where wells will be drilled. Cost over $50,000.

STANDARD OIL CO. OF CALIFORNIA, 225 Bush St., San Francisco, has contracted Riley Stoker Corp., Los Angeles, for 3 125,000-lb. per hr., high-pressure boilers and G.E. for three 4,000-kw. turbo-generators for its Richmond refinery. Stone and Webster Engineering Corp., Russ Bldg., San Francisco, consulting engineer.

RALPHS GROCERY CO., Los Angeles, Calif., plans cold storage and refrigerating plant in one-story market building at Santa Monica Blvd. and Randall Court to cost about $50,000. Morgan, Walls & Clements, Van Nuys Bldg., architects.

SIERRA MOUNTAIN WATER CO., 410 East Market St., Stockton, Calif., has applied for permission to use water from Cosumnes River, Amador County, totaling 300,000 acre-feet per year, for power. Station will have estimated capacity of 13,840 hp. Will cost over $700,000.

NORTHWESTERN NATURAL GAS CO., Yakima, Wash., plans welded-steel pipeline from natural gas fields near Rattlesnake Hills, Yakima County, to Yakima and vicinity, about 80 miles. Compressor stations will be built along route. Will cost over $400,000.

PORTLAND, ORE., plans central pumping station and power house for sewage disposal system. Bond issue of $6,000,000 arranged.

STATE BOARD OF CONTROL, Capitol Bldg., Salem, Ore., Daniel Fry, secretary, plans power plant for central heating of eight State buildings. Generating division is proposed for light and power service. $450,000 voted by Legislature, of which $206,300 will be Federal grant.

Canada

NOVANDA (Quebec) POWER CO., LTD., is planning hydro-electric plant on Upper Ottawa River in Temiskaming County to insure uniform supply to waterworks system and mills. To cost over $1,000,000.

ONTARIO HYDRO-ELECTRIC COMMISSION, Toronto, Ont., J. Stewart Lyon, chairman, plans to secure privately owned plant in Ontario by acquisition of Canadian Niagara Power Co. Ogoki development will be undertaken, enabling $2 per hp. rate on Niagara system.

GATINEAU POWER CO., New Brunswick, will construct a 10,000-hp. turbo-generator at Dalhousie.

NOVANDA MINES, LTD., Royal Bank Bldg., Toronto, Ont., has James C. Meadowcroft, 1154 Beaverhall Hill, Montreal, Quebec, preparing plans for concrete power-house and other buildings to cost over $100,000.

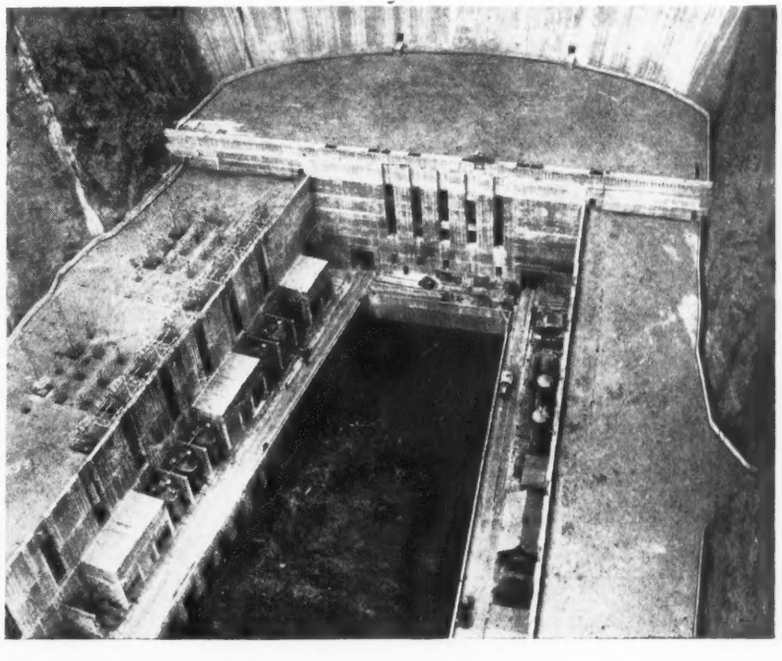
CARIBOU GOLD QUARTZ CO., Wells, B. C., Dr. W. B. Burnett, president, will build $163,000 power plant.

ONTARIO PAPER CO., St. Catherines, Ont., has contracted Foundation Co. of Canada, Ltd., Montreal, for 60,000-hp. hydro-electric development on Ontario River, transmission line to mill at Baiecomeau, development of logging operations on Manicougan River, and construction of a mill and townsite at Baiecomeau to be completed by June 1, 1938, at cost of $8,000,000. A. A. Schmon, general manager.

BEHIND TONS OF WATER

Boulder Dam power house as seen from a skip suspended on cables above the dam. Power units are being installed. Entrances on top of central section lead to inspection galleries inside dam

Acme



AXLE TAPPERS . . .

The old timer had just been handed a gold watch in recognition of 50 years of service as a railroader. Concluding a lengthy appreciation of the old timer's faithfulness and devotion to duty, the president said, "Now, Mr. Blank, won't you tell us what your job is?"

"Why, Mr. President, I'm an axle tapper. I go from car to car tapping the axles as the trains come in."

"What for, Mr. Blank?"

"I don't know—somebody told me to do it when I was hired 50 years ago."

Faithfulness? Yes. Devotion to duty? Yes. But intelligent application to the job in hand? Absolutely no! He was simply following the crowd—"his not to reason why, his but to tap and die," or something like that.

I'm reminded of axle-tapper story by the recent comment of an engineer, "It's no use to suggest anything new to the Boss; he won't listen. It's better just to go on doing things that have to be done and keep my mouth shut." His philosophy is all right, and will work—until that not-too-far distant day when the plant blows up into his lap. Then he's probably offended when somebody holds him responsible.

An axle tapper may be hired just to tap axles, and a street cleaner to clean streets, but an engineer is hired to *operate* a plant. And operating a plant means doing a little thinking about it as well as just starting things that need starting and shutting off things that need stopping. We've got to do a little planning too, to figure on tomorrow as well as today. That may mean we stick out our necks a little, but even a turtle would never get anywhere if he didn't stick his neck out once in a while.

George Edwards

GEORGE EDWARDS,
Engineer.